AUGUST 1955

Journal

VOL. 47 • NO. 8

AMERICAN WATER WORKS ASSOCIATION

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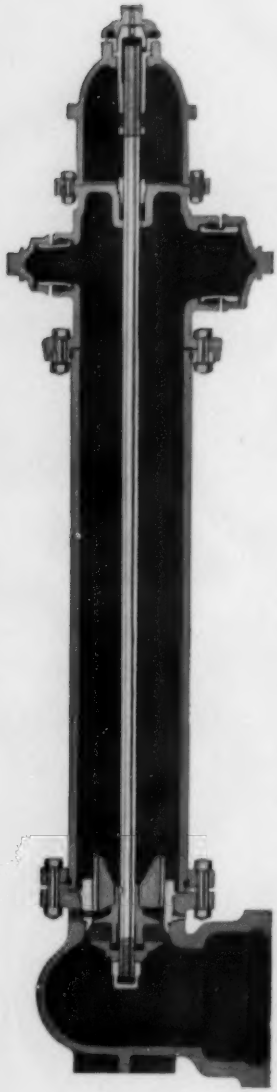

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Journal

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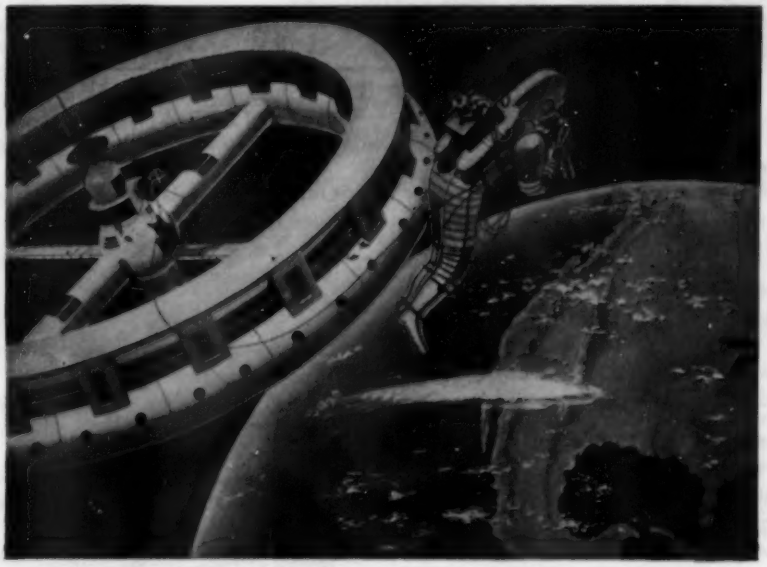

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Coming Meetings

AWWA SECTIONS

Sep. 7–9—New York Section at Saranac Inn, Saranac. Secretary, Kimball Blanchard, Rensselaer Valve Co., 56 Grand Street, White Plains.

Sep. 12–14—Kentucky-Tennessee Section at Phoenix Hotel, Lexington, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, 553 S. Limestone St., Lexington.

Sep. 14–16—Michigan Section at Durant Hotel, Flint. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, Lansing 4.

Sep. 19–21—Rocky Mountain Section at Connor Hotel, Laramie, Wyo. Secretary, J. W. Davis, Dist. Mgr., Transite Pipe Div., Johns-Manville Sales, Inc., Denver, Colo.

Sep. 21–23—Ohio Section at Neil House, Columbus. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

Sep. 21–23—Wisconsin Section at Hotel Schroeder, Milwaukee. Secretary, Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3.

Sep. 25–27—Missouri Section at the Connor Hotel, Joplin, Mo. Secretary, W. A. Kramer, Room 3, 6th Floor State Office Bldg., Jefferson City, Mo.

Oct. 5–7—North Central Section at Radisson Hotel, Minneapolis, Minn. Secretary, Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Oct. 16–19—Southwest Section at Gunter Hotel, San Antonio, Tex. Secretary, Leslie A. Jackson, Mgr.-Engr., Munic. Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 19–21—Iowa Section at Hotel Fort Des Moines, Des Moines. Secretary, H. V. Pedersen, Supt., Water Works, Munic. Bldg., Marshalltown.

Oct. 20–21—West Virginia Section at Waldo Hotel, Clarksburg. Secretary, Harry K. Gidley, Director, Div. of San. Eng., State Health Dept., Charlestown.

Oct. 20–22—New Jersey Section at Hotel Madison, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan Inc., Box 178, Newark 1.

Oct. 25–28—California Section, at Senator Hotel, Sacramento. Secretary, H. F. Jerauld, Asst. Supt., Constr. & Operation, Water Dept., 1040 Manzanita Ave., Pasadena 3.

Oct. 26–28—Chesapeake Section, at Sheraton Park Hotel, Washington, D.C. Secretary, Carl J. Lauter, 6955—33rd St., Washington 15, D.C.

Oct. 30–Nov. 2—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

(Continued on page 8)

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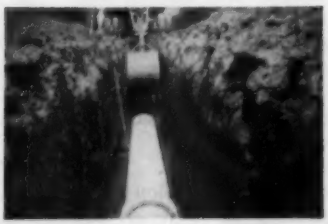

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Coming Meetings

(Continued from page 6)

Nov. 3–5—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, J. P. Kavanaugh, 213 Carlton Terrace Bldg., Roanoke 11.

Nov. 6–9—Florida Section, at Orange Court Hotel, Orlando. Secretary, Harvey T. Skaggs, Secy. & Gen. Mgr., Amica Burnett Chem. Co., Box 2328, Jacksonville.

Nov. 14–16—North Carolina Section, at Robert E. Lee Hotel, Winston-Salem. Secretary, W. E. Long Jr., 1615 Bickett Blvd., Raleigh.

OTHER ORGANIZATIONS

Aug. 15–19—Water and Sewage Plant Operators Short Course, at Virginia Polytech. Inst., Blacksburg. Administrator, J. D. Eye, Prof. of San. Eng., V.P.I.

Sep. 12–16—Short Course on Corrosion, at Washington Univ., St. Louis, Mo., sponsored by Washington Univ. and Greater St. Louis Section, National Assn. of Corrosion Engrs.

Sep. 18–22—New England Water Works Assn., at Lake Placid Club, Lake Placid, N.Y.

Sep. 21–23—Georgia Water and Sewage School, at Hightower Textile Bldg., Georgia Inst. of Technology, Atlanta.

Oct. 10–13—Federation of Sewage & Industrial Wastes Assns., at Ambassador Hotel, Atlantic City, N.J.

Oct. 24–28—American Society of Civil Engineers Convention, at Hotel Statler, New York.

Oct. 24–26—National Conference on Standards, at Sheraton Park Hotel, Washington, D.C., sponsored by National Bureau of Standards and American Standards Assn.

Nov. 1–3—Panel Conference on Underground Structure Corrosion, at Hotel Niagara Falls, N.Y., sponsored by Northeast Region, National Assn. of Corrosion Engrs.

Nov. 14–18—American Public Health Assn. Convention, at Municipal Auditorium, Kansas City, Mo.

Nov. 16–18—Water Works Management Short Course, at Univ. of Illinois, Allerton Park, Ill.

Nov. 27–30—American Institute of Chemical Engineers, at Hotel Statler, Detroit, Mich.

Nov. 27–30—National Chemical Exposition, at Public Auditorium, Cleveland, Ohio, sponsored by Chicago and Cleveland sections, American Chemical Society.

Dec. 5–9—Exposition of Chemical Industries, at Commercial Museum and Convention Hall, Philadelphia, Pa., under management of International Exposition Co., New York.

Dec. 11–17—Nuclear Engineering and Science Congress, Cleveland, Ohio, sponsored by Engineers Joint Council.

1956

Feb. 13–18—Symposium on Winter Concreting Theory and Practice, International Union of Testing & Research Labs. for Materials & Structures (RILEM), Copenhagen, Denmark. Organizing Secy., RILEM Symposium 1956, c/o Danish National Inst. of Building Research, 20 Borgergade, Copenhagen, K, Denmark.

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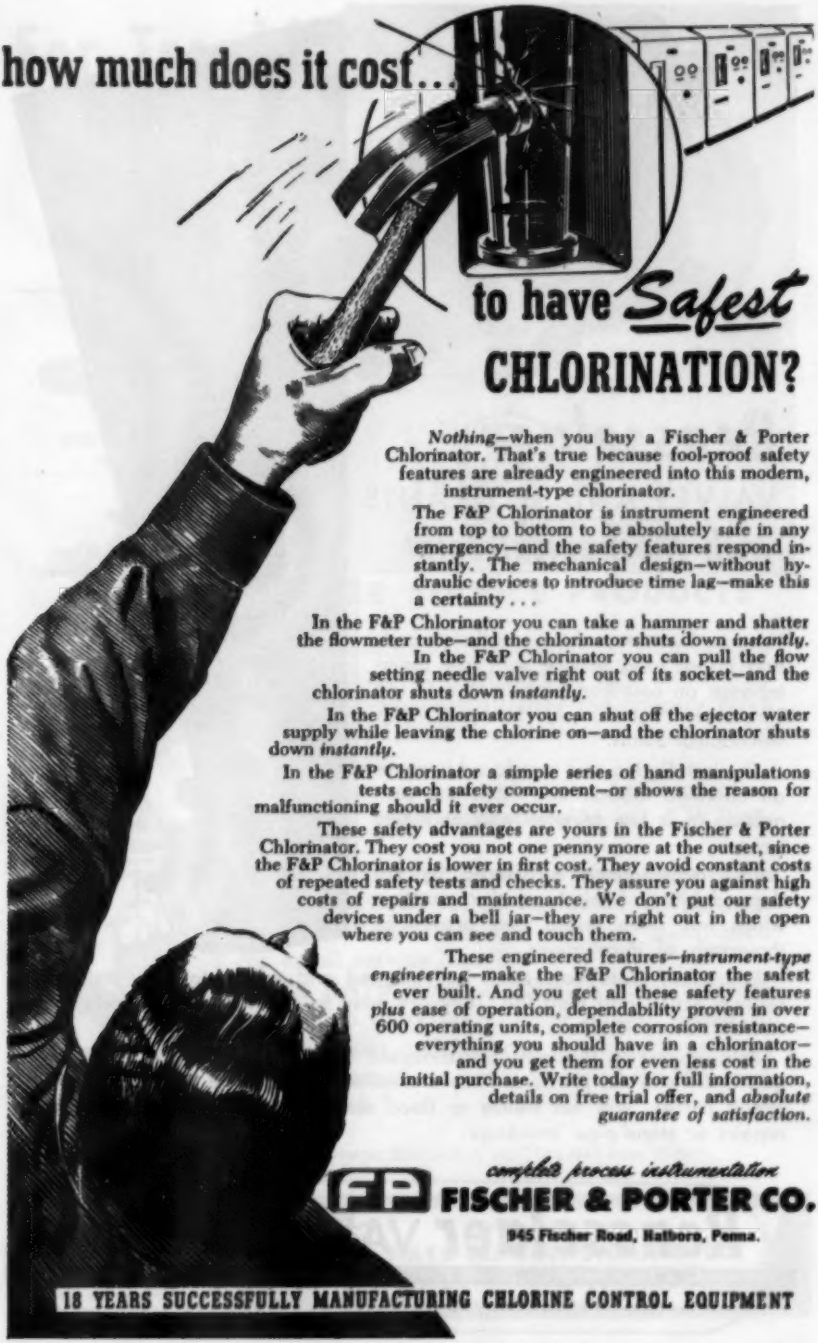

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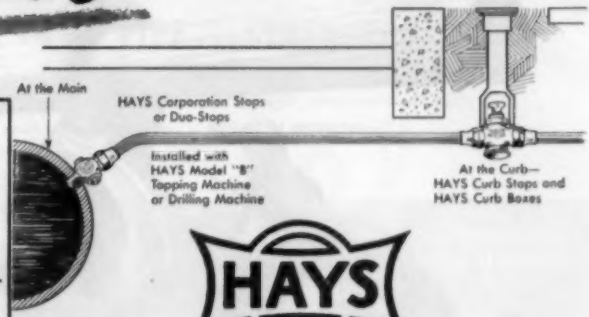
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The HAYS Model B Tapping Machine, with aluminum alloy body, is ⅓ lighter, easier to carry, easier and faster to operate, gives more working room . . . really designed for "the man in the ditch."

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Join the A. W. W. A. HAYS is one of the eleven Charter Members of the Manufacturers Section of the American Water Works Association.

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WATER WORKS PRODUCTS

HAYS MANUFACTURING CO.

ERIE, PA.

what have

The Asiatic elephant is found in shady, wooded districts of Southeastern Asia. Huge animals that weigh up to 8,000 pounds and have a life span of about 60 years, they are easily domesticated. Many of them are used to perform useful labors of lifting and pulling. Ordinarily gentle, they can become highly dangerous when enraged or frightened.

In good condition after 100 years of service, this cast iron distribution main is one of several still functioning in New York City.

MODERNIZED **cast iron**

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THE ELEPHANT AND CAST IRON PIPE...STRENGTH!

Great strength has made the elephant one of Man's most useful animals. And Cast Iron's strength . . . shock strength, beam strength, compressive strength, make it the world's most dependable pipe . . . servant of centuries.

AND HERE'S THE PROOF: Listed below are some of the many water utilities still using cast iron pipe that was installed a century or more ago.

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TODAY... modernized cast iron pipe, centrifugally cast, is even tougher, stronger, more uniform. *Where needed and specified,* it is centrifugally lined with cement mortar to assure sustained carrying capacity throughout its long years of service.

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CAST IRON

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pipe FOR MODERN WATER WORKS OPERATION

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The disc in this 84-in. low pressure Butterfly Valve must withstand 138,000 lbs. of force when closed against a 25 P.S.I. line pressure . . . yet the face to face dimension is only 18 in. and the entire valve weighs just 12,000 lbs. Even under this severe loading Pratt design keeps the bearing pressure well below 2500 P.S.I.

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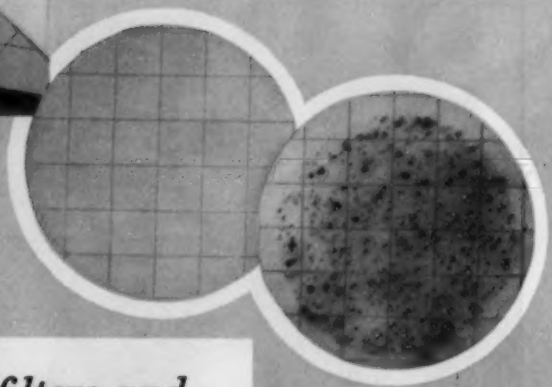

Coli 5 Apparatus *(above)* **for the filtration of bacteria, and other microorganisms**

"Bac-T-Flex" is a trademark

New membrane filters and membrane filter techniques

The filters pictured above and similar membranes can be used for the determination of numbers and types of bacteria and other microbes in water, sewage, milk, foods, beverages, air and soil; for the detection and isolation of *Mycobacterium tuberculosis* from sputum or other materials; and for the filtration of fine particles from suspensions.

Membrane filter techniques save labor, time, materials and equipment. They are proving more efficient and accurate than other methods for the determination of coliform and pathogenic bacteria in water.

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Note these important advantages

1. **Flexible, durable, easy to handle and sterilize.**
2. **Green grid makes counting of colonies easy and accurate.**
3. **Large grid size facilitates counting using magnifications up to 15 times.**

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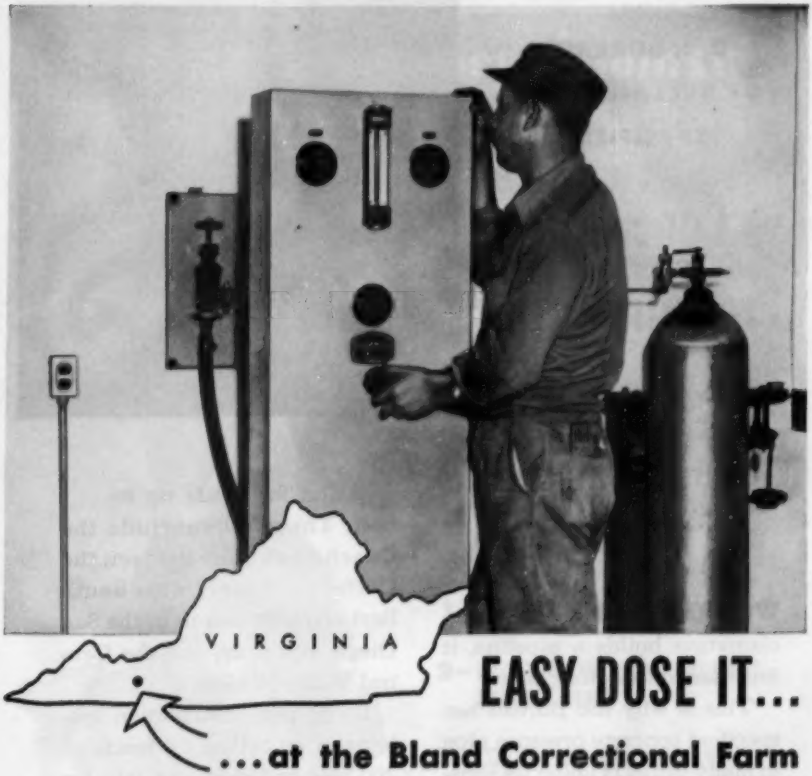

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Operating personnel at the Bland Correctional Farm in White Gate, Virginia, report this Builders Model DVS Chlorinizer has been mighty easy to work with ever since it was installed in early 1951. Due to Chlorinizer's positive-acting chlorine control system, plant personnel have been able to set the chlorine dosage at the exact rate required by their water sterilization needs.

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Hundreds of performance reports like this are coming in from Chlorinizer users in municipalities, institutions, and industries throughout the country. If you are considering new chlorination capacity, or replacement of present chlorination equipment, why not check your nearest Chlorinizer installation. We will be glad to send you a list of Chlorinizer users in your area . . . and also bulletins describing the four basic Chlorinizer models. Write, today, to Builders-Providence, Inc., 365 Harris Avenue, Providence 1, Rhode Island.

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This is why the Bureau has specified concrete pressure pipe in many projects under its jurisdiction throughout the Western States. In the State of California alone, approximately 3,000,000 feet of concrete pressure pipe have been used in diameters ranging from 12″ through 84″, and for heads up to [illegible] feet. These jobs include the Coachella Valley Project, the Cachuma Project near Santa Barbara, both barrels of the San Diego Aqueduct, and the Central Valley Project.

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Member companies manufacture concrete pressure pipe in accordance with nationally recognized specifications

Concrete PRESSURE Pipe

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All Smith Hydrants are equipped with Compression Type Valves which definitely eliminate flooding since the line pressure holds the Valve against its seat in the closed position.

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Does the COAGULANT You Are Now Using Have These Advantages?
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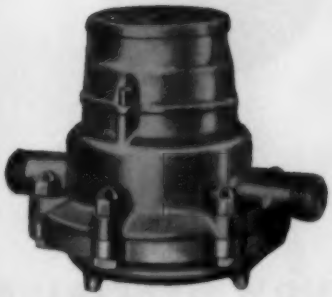

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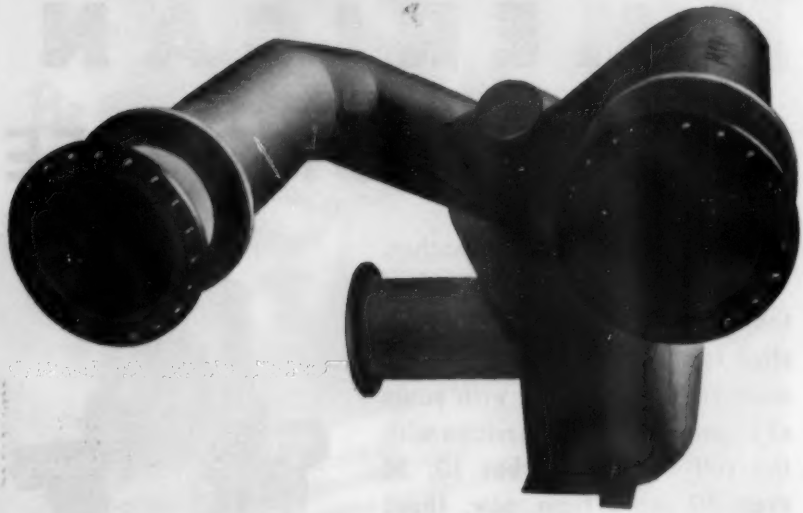

HOW SPECIAL ARMCO FITTINGS SAVE TIME AND MONEY IN WATER WORKS PIPING

Looking more like a grotesque claw than part of a water works piping system, this special Armco fitting is being loaded for shipment to a Midwest city. It will do the work of some seven individual fittings. This means fewer pieces to handle at the site, and the elimination of at least six sets of flanges—more savings in both time and money.

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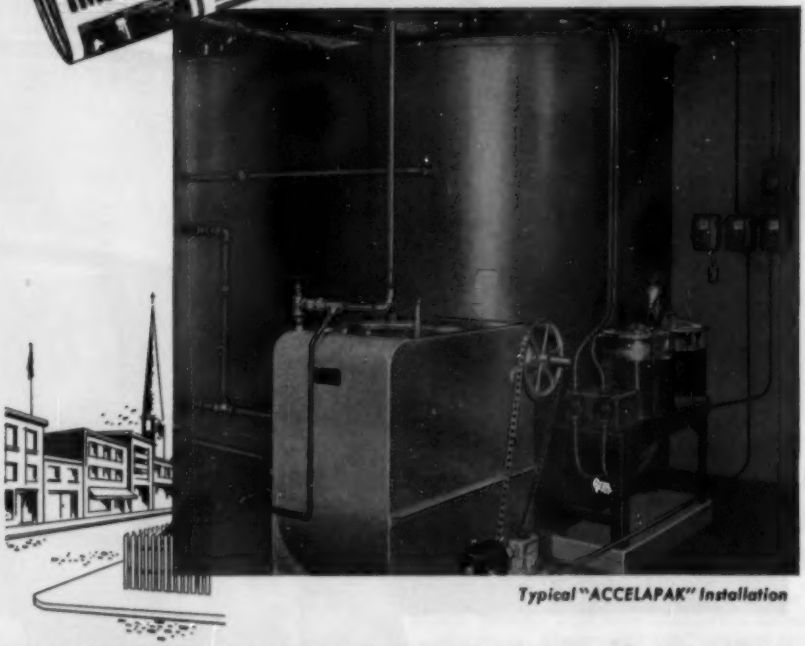

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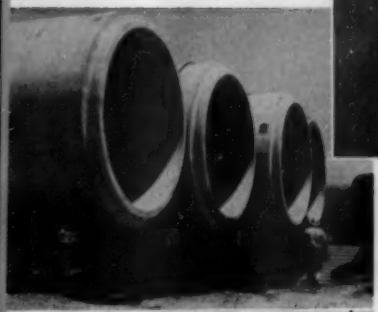

Temporary trestle provides runway for gantry crane. Pipe sections are lowered into position through trestle.

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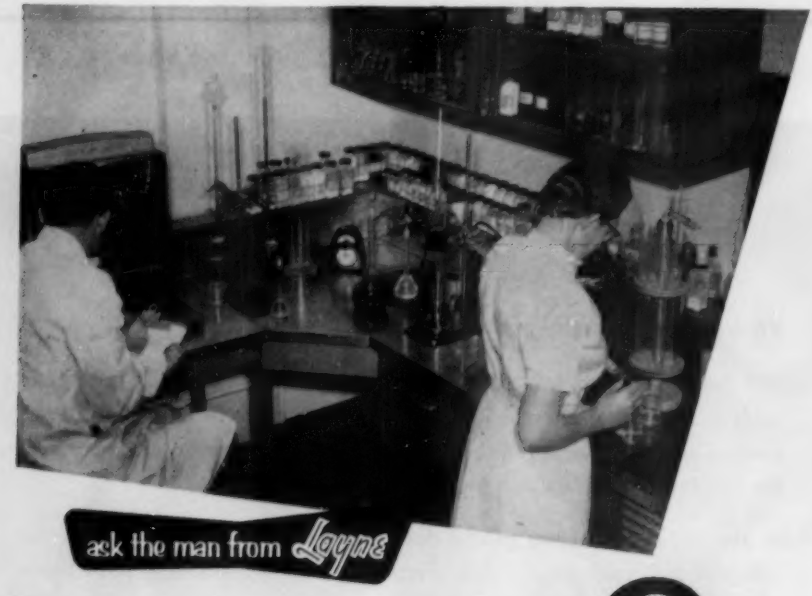

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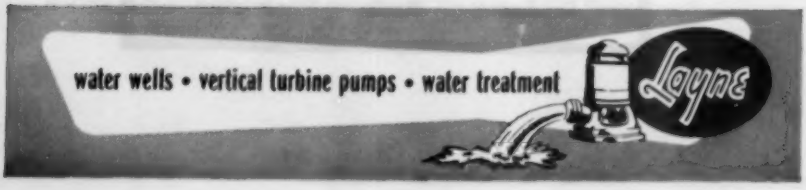

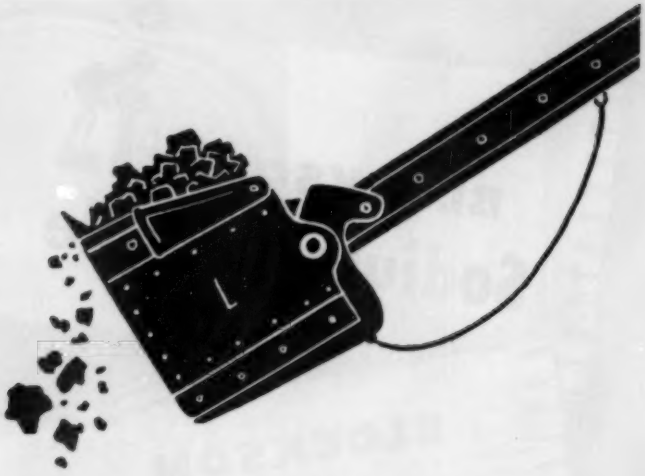

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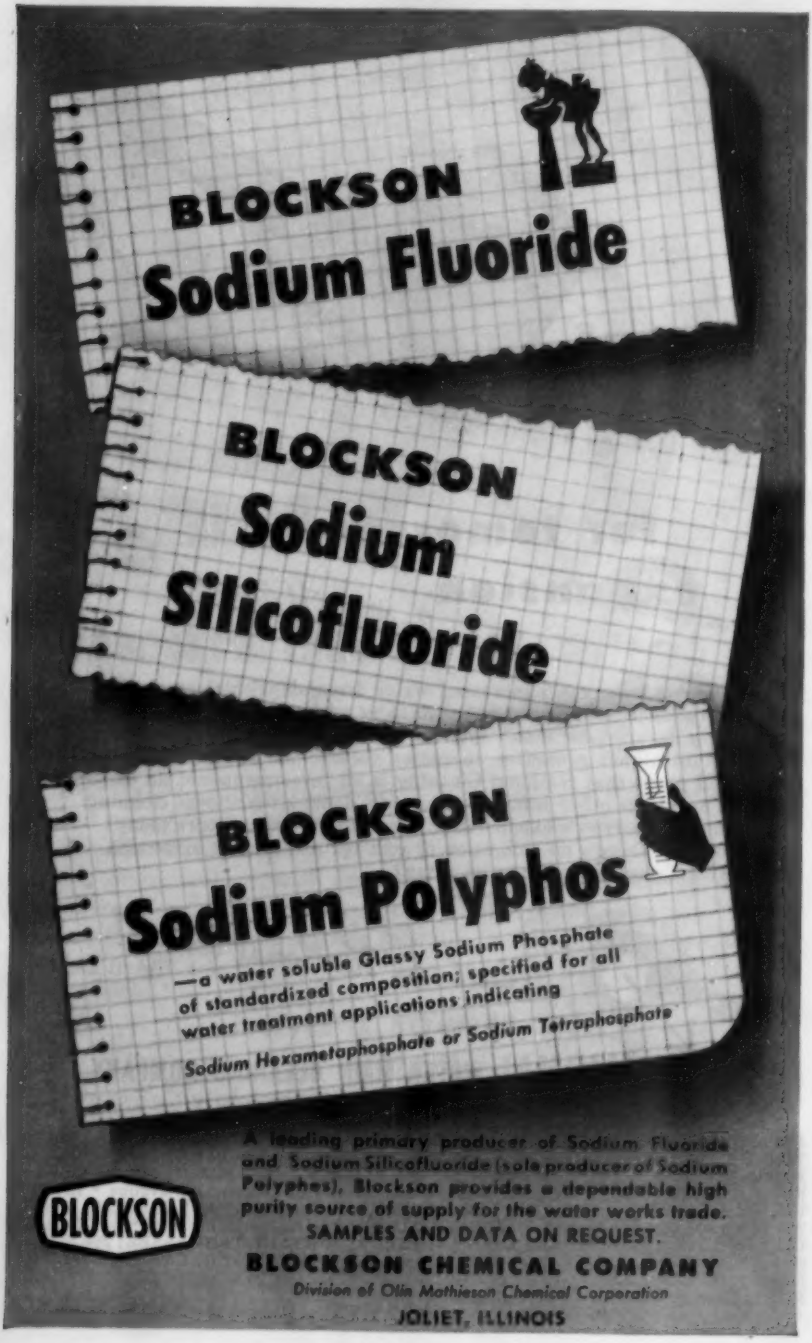
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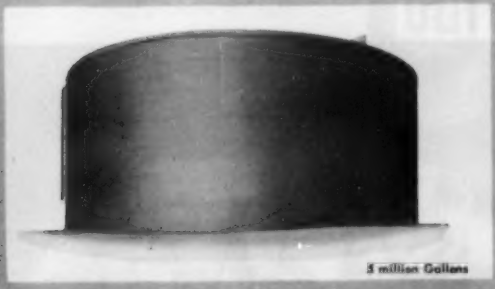

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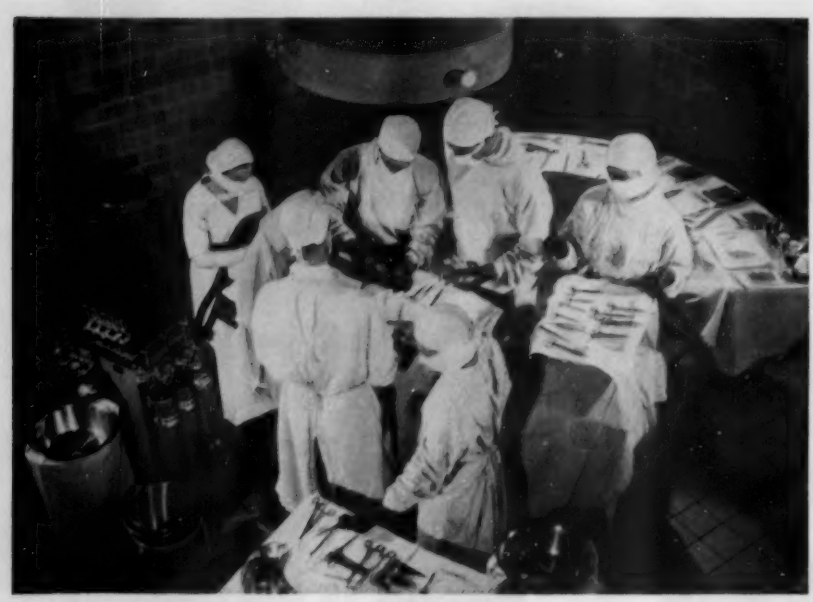

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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 47 • AUGUST 1955 • NO. 8

Current Trends in Treatment Plant Design

Louis R. Howson and William W. Aultman

A paper presented on Feb. 10, 1955, at the Indiana Section Meeting, Indianapolis, Ind., by Louis R. Howson, Partner, and William W. Aultman, Engr., both from Alvord, Burdick & Howson, Chicago, Ill.

EVERY part of a treatment plant should perform its proper share of the clarification and purification work. The present trend in water treatment plant design seems generally to stress better and more efficient methods of pretreatment, thus, reducing the burden on the filters. Such improvement is justified where filters are heavily relied upon to treat grossly polluted water. In most plants, however, the filters are used primarily for a final polishing that removes the last trace of turbidity, leaving the water sparkling clear. Where this is true there is no need to relieve the filters of their load by pretreating the water until it is almost at the desired clarity going on the filters, particularly if such a procedure increases the cost of plant construction and operation.

Today, the public is much more conscious of the quality of water, especially its taste and hardness, than at any time in history. Greater taste consciousness is largely the result of progress within the public water supply industry; greater appreciation of soft water is partly due to the promotion of rented household water softeners and to advertisements by manufacturers of synthetic detergents.

Managers and operators of water systems must be constantly alert not only to produce a safe water continuously, but also to improve its quality in terms of standards the ordinary citizen can readily evaluate.

Among the treatments and processes which must be subjected to constant consideration in designing treatment plants are the following:

Intakes

Frazil ice frequently interferes with lake intakes in cold climates. Such trouble in the Great Lakes region is greatly reduced or eliminated if the intake extends to a 40-ft depth of water and the structure is designed to insure that the velocity at the intake ports never exceeds 3 ips. Maintenance of low velocities has also materially reduced intake clogging and difficulties with mechanically cleaned screens.

Presedimentation

Modern design seldom calls for the use of presedimentation basins, as improvement in coagulation procedures and the successful operation of continuous sludge removal equipment in sedimentation basins has largely eliminated the need for presedimentation in even the most turbid waters.

Mixing and Coagulation

Today, it is understood that both time and velocity are essential elements in the mixing and settling processes of water treatment. Rapid mixing devices are less frequently used than formerly, particularly when lime is employed in the treatment process. With the lime a hard, very thick deposition of calcium carbonate quickly builds up where the relative velocity is high between the water and the mixing device or channel wall. Because of the realization that uniform mixing velocities should be maintained regardless of the rate of flow through the plant, the use of the baffle type of coagulation basin has been almost abandoned and many such units are being modified to take mechanical equipment.

Although many mechanical types of mixing devices are available, there appears to be little difference in the results obtained from them as long as thorough chemical dispersion and proper flow velocity can be achieved. Because the optimum velocity may change with variation in water temperature, water quality, or treatment method, all equipment must allow the attainment of any desired velocity. The best velocity cannot always be determined precisely from laboratory trials, but must be ascertained from actual plant operation. A detention time of 30–60 min is provided in the mixing basins of most modern installations.

Sedimentation

Because the length of the overflow weir is of major importance in the conventional sedimentation basin, a circular or square basin is the most advantageous shape. They have the longest perimeter per unit of volume. In some rectangular basins it has been found desirable to construct finger overflow weirs in order to increase the weir length and decrease the overflow rate, which should be kept at less than 20,000 gpd per foot of weir, if possible.

Although the detention period is influenced by raw-water turbidity, temperature, and, in softening, by mineral content, the present tendency, generally, is to increase the detention time on conventional sedimentation basins to 3–5 hr. Today's better mixing and continuous sludge removal, obviating sludge accumulation, allow the constant availability of full basin capacity and thus reduce the variation in detention period required for turbid waters.

After addition of chemicals in a softening plant, the velocity of flow should be maintained at a uniform rate and even restricted gate openings should be kept to a minimum to prevent the accumulation of heavy calcium carbonate deposits on the walls of the channels of basins.

Sludge Removal Equipment

The necessity for sludge removal equipment is always debatable. In softening plants where large quantities of sludge are produced, such installations are essential to maintain the necessary continuous operation of the plant without large capital expenditures for extra basins that permit the shutdown of one set for cleaning without reducing the required capacity. Because much smaller quantities of sludge are

produced in other types of treatment plants, special apparatus for removal is not needed.

From an economic standpoint, mechanical sludge removal equipment cannot usually be justified unless a high value is placed on the desire to eliminate a periodic and messy cleanup. A study of the new 960-mgd capacity Central Dist. Filtration Plant at Chicago, showed that the inclusion of automatically cleaned basins would add $2,190,128 to the investment, raise operating costs by $3,623 per year, and increase the total annual costs—including operation, interest, and depreciation—by $174,777. Despite such costs, there is an increasing tendency to install mechanical sludge-removing equipment, because of the mounting cost of labor and the desire to avoid distasteful cleaning.

Suspended-Solids Contact Basins

A major question in recent years has been whether to use conventional mixing and sedimentation basins or the new suspended-solids contact ("upflow") clarifiers. The choice is determined, in the last analysis, by the type of water and method of treatment, as well as by an evaluation of working efficiencies, flexibility, and results, in terms of cost.

The various manufacturers have adopted different designs in offering equipment for sale. Keen competition has resulted in the recommendation of low contact periods and high rates of flow, reducing the ability to absorb shock loads. Although detention periods of 1–1½ hr are now generally suggested, experience has indicated that a period considerably longer than this should usually be provided when treating water with much noncarbonate hardness, particularly when magnesium salts are an important constituent and the supply is drawn from surface sources in the northern part of the United States. It is believed that an upflow rate not exceeding 1 gpm per square foot of surface area, with a minimum detention of 2 hr, represents sound practice in operating suspended-solids contact clarifiers.

A study of the capacity and loadings of suspended-solids contact clarifiers was made over a period of more than

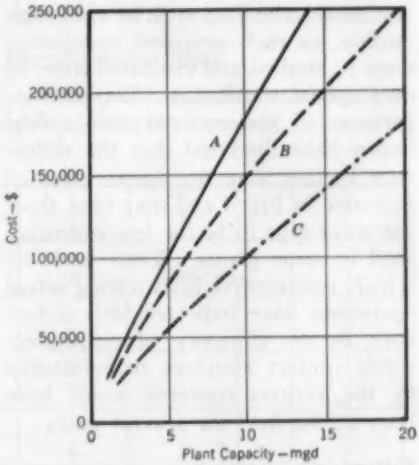

Fig. 1. Costs of Conventional and Suspended-Solids Contact Clarifiers

Costs were based on an Engineering News-Record *Construction Cost Index value of 475.* A—*Upflow unit, 2-hr detention time;* B—*conventional unit, 4-hr settling period;* C—*upflow unit, 1-hr detention time.*

3 years by an AWWA committee (*1*), which concluded that the upflow unit is particularly adaptable to calcium carbonate precipitation reactions. The committee further stated that although it is theoretically possible to produce a softened water which is chemically stable in calcium carbonate whenever sufficient calcium carbonate surface and time are provided, there is no evidence that such stability is generally obtained.

Any comparison of the costs of conventional and suspended-solids contact clarifiers is greatly influenced by the detention time. Figure 1 compares estimated costs of conventional clarifiers having 4-hr settling periods with suspended-solids contact clarifiers having both 1- and 2-hr detention periods. Because the information contained in this graph pertains to specific conditions that existed at the time of investigation, the data must be used with caution, as each proposed installation must be studied and evaluated from its own special standpoint. Recent comparisons of conventional and upflow basins have disclosed that the difference in cost may not be as great as indicated in Fig. 1 and may even show the latter type to be the less expensive kind in some plants. Tests made on a truly comparative basis during actual operations have indicated little difference in the efficiency of suspended-solids contact clarifiers manufactured by the various concerns which have been in the field for several years.

Filters

The major disagreement in the design of rapid sand filters is about the proper rate of filtration. Although the conventional rate, originally adopted as a result of the pioneer Louisville experiments by George W. Fuller, is only 2 gpm per square foot of filter area, the work of John R. Baylis at Chicago (*2–4*) has shown that a rate as high as 5 gpm per square foot can be tolerated if the water is properly conditioned before reaching the filters. A number of plants which were of appropriate hydraulic design and relatively free of algae troubles have been periodically operated at high rates. The Moffatt Filter Plant at Denver has been run several months annually for 15 years at rates of more than 3¾ gpm per square foot. As most surface waters have occasional algae troubles that cannot wholly be controlled by coagulation, however, conservative practice still insists that most filter plants be operated at 2 gpm per square foot, although the plant hydraulics may allow a peak rate of 4 gpm per square foot.

The difference in cost between a filter plant designed for 2 gpm per square foot and one of 3 gpm is only 5–7 per cent. Because both can operate at a 4-gpm peak rate, with proper hydraulic design, this small increased cost provides three times the peaking-rate flexibility, if needed, as well as greater assurance of maintaining production at any algae condition likely to occur.

Underdrains. Despite the large number of patented filter underdrain systems on the market, experience has shown that there is little practical difference between most of them and conventional pipe lateral systems. Although the proper type of underdrain for any installation should be determined from an economic evaluation of all factors at the location under study, it is possible that the availability of materials and the contractor's or owner's preference may decide the selection.

Sand Size. Largely as a result of John Baylis' research and the experience in his and many other plants in recent years, the present tendency is to specify a somewhat coarser filter sand than formerly. An effective size of 0.45–0.55 mm and a uniformity coefficient of 1.3–1.7 gives good results when the water is properly treated ahead of the filters. Sufficient backwash water should be provided to give a sand expansion of at least 50 per cent, a procedure which generally requires—depending upon the tempera-

ture of the water—a wash rate equal to a rise of 24–36 in. per minute.

Surface wash facilities, included in most recent fiber installations, are essential in treating all turbid waters. As the availability of surface wash results in the need for less sand expansion, the total wash rate—for both back- and surface wash—rarely exceeds 30 in., of which $\frac{1}{8}$–$\frac{1}{3}$ is for surface wash. The use of a fixed or a movable type of surface wash is a matter of overall comparative cost, because either system, if properly designed and operated, gives satisfactory results.

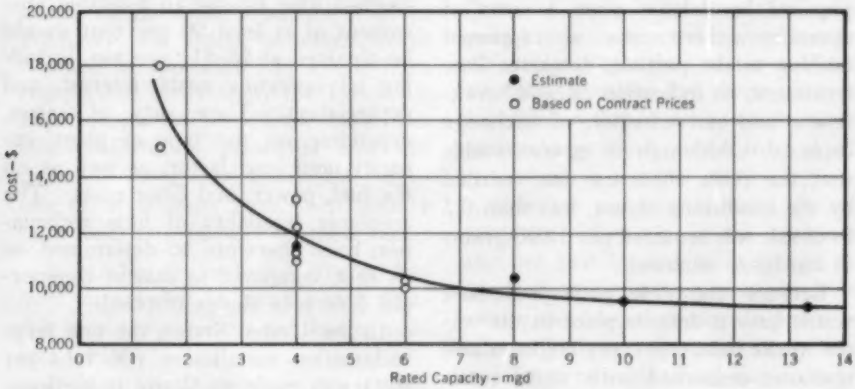

Fig. 2. Filter Size and Cost of Equipment

The filter capacity was rated at 2 gpm per square foot. Costs were based on an Engineering News-Record *Construction Cost Index value of 612. The cost includes installation of gallery piping.*

Valves. Hydraulically operated valves generally give less trouble than electrically operated ones in treatment plants, apparently because the high humidity in a water works tends to cause a more rapid breakdown in the electrical equipment.

A marked economic saving is effected by using the largest filter units that will give the desired flexibility. The relationship between cost of filter equipment and size of units is presented in Fig. 2, but the overall saving is much greater, as shown in a recently built 36-mgd plant, where the use of 6-mgd units instead of 4-mgd units saved $109,000. Studies made for the 960-mgd plant at Chicago indicated decreasing costs per 1 mgd for filters up to 10 mgd. The largest ones in existence at present are at Milwaukee, with a capacity of 6¼ mgd based on a rate of 2 gpm per square foot.

Murphysboro Plant

A unique installation was made in 1951 at Murphysboro, Ill., in a small plant that treated a surface water with a total hardness of 100–500 ppm (averaging 270–350 ppm annually) and with a turbidity over 1,000 ppm at times. After treatment with lime to raise the pH and to remove about 4 ppm manganese and some carbonate hardness, the water is settled, leaving a hardness of 140–320 ppm.

Originally, the plant had four sand filters with a rated capacity of 0.5 mgd

each, but in order to reduce the hardness further, the sand in two units was replaced with a polystyrene-base resinous cation exchanger. These were operated in parallel with the sand filters, with the somewhat turbid settled water passing through the resinous filter in the same manner as through the sand filter. The proportion of flow between the two types was adjusted to give the desired hardness of 85 ppm in the blended, finished water. The resinous units are backwashed in the same manner as the sand filters, regenerated with brine, and rinsed out.

When samples of the resin were analyzed for particle size and possible physical breakdown after 3 years of operation, there was no apparent buildup in the particles from the lime treatment, no indication of bead breakdown, and no reduction of exchange capacity. Although it is conceivable that the resin efficiency was reduced by the conditions of use, less than 0.3 lb of salt was required per 1,000 grains of hardness removed.

Because the new polystyrene-base resins have a definite place in the water works industry, every engineer and operator concerned with water treatment should keep abreast of the progress made in the perfection of operating techniques and potential uses for this material. Where brine wells are available or if the installation is along a coastline, application of these resins should be investigated. The newly developed method of continuous regeneration of cation exchangers should also be considered.

Lime Reclamation

No discussion of the trends in treatment plant design would be complete without mention of the progress being made in the reclamation of lime from calcium carbonate softening-plant sludge. To date, no process has been thoroughly proved to be economical for a small installation. For plants with a capacity of more than 20–40 mgd, depending on the hardness of water treated, recovery has been shown practical, and the procedure has generally saved money except at locations where lime is inexpensive.

Because of the small number of plants which now reclaim lime, insufficient data are available to establish positively the cost of such lime under all conditions of operation. The indications, however, are that reclaimed lime having an available lime content of at least 90 per cent should be obtained at $8–$11 per ton, including all operating costs, interest, and depreciation. These vary, of course, depending on the type of plant, capacity, and load factor, as well as on the fuel, power, and labor costs. The economic feasibility of lime reclamation must therefore be determined on its cost, compared to that of commercial lime plus sludge disposal.

In the United States, the first large reclamation installation (80 tons per day) was made at Miami in conjunction with a 60-mgd softening plant. The recovery plant represented an investment of nearly $800,000, but the savings in lime paid back the amount in about 4 years. Although the sludge at this plant contained mostly of calcium carbonate sludge which contains magnesium salts has also been satisfactorily recalcined in continuous operations by the use of a centrifuge type of dewatering equipment with which the potential buildup of the undesirable magnesium salts can be greatly reduced or eliminated.

The calciner at Miami is a rotary kiln, which is suitable for only rela-

tively large installations. Tests of a new type of calciner pilot plant,* of a capacity of 6 tons per day, at Lansing, Mich., resulted in the recent completion of a 30-ton-per-day unit at this location. This type of calciner may possibly be adaptable to installations of smaller size than can be justified for a rotary kiln. Equipment for small plants is greatly needed, not only to reduce the cost of treatment in favorable locations, but also to eliminate or reduce the constant problem of sludge disposal.

Conclusion

Because progress in water treatment, as in most processes, evolves gradually, the extent of advancement can best be appreciated by a long-term comparison. Although the Louisville experiments established the basic mechanical-filtration principles that are generally recognized today, the methods of application have been greatly improved, as evidenced by these facts:

1. Mixing by velocity change has been superseded by more direct, flexible mechanical means and longer contact periods.

2. Mechanical cleaning of settling basins for turbid waters and those involving the use of lime for softening or clarification has not only reduced the required basin capacity, but also produced a better water going to the filters.

3. The hydraulic design of filter bottoms has been greatly improved.

4. Sand cleaning, formerly done by mechanical agitation and air scrubbing, and later by high-rate backwashing regulated by sand expansion, is now generally being accomplished at more moderate upflow rates with scrubbing by low-cost surface wash systems.

5. Chemical feeding, originally by solution only, has become an almost completely dry procedure with the development of suitable equipment, although many larger plants are now switching back to solution feed for alum, making some use of commercial liquid alum.

6. The control of taste and odor has become so commonplace that many plants spend more for chemicals for that purpose than for disinfection.

Much of the constantly increasing knowledge about the chemistry of water is reflected in plant improvement. There is some indication that treatment has been directed toward turning out a highly polished water and that too little attention has been given to the effect of that water upon the mains constituting about two-thirds of the investment in a water works.

Although progress is made through combined effort, it is the operators who are best located to undertake the constant study of variations in treatment procedure that may improve results. If these men pass along what they learn to others, and engineers incorporate the advances in the design of new plants and additions, the water works field will continue its progress of the past century.

* Equipment involved was manufactured by Dorr-Oliver Inc., Stamford, Conn.

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Discussion

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The proprietary basins that incorporate mixing, coagulation, and separation of solids from water in a single unit are now used in hundreds of water treatment plants throughout the United States. These installations are supplied by at least eight highly competitive companies. A 1951 report of an AWWA committee (*1*) helped to evaluate the suspended-solids contact basin, pointed out the extreme difference in opinion between people concerning the upflow type, and emphasized that there is much to be learned about the new basins.

Although the Appleton, Wis., Water Works has had two suspended-solids contact softeners of different types in operation for more than 7 years, water flow measurements to the units have not been sufficiently accurate to permit a reliable comparison of relative performance. Lime is used in excess as a softener, while alum and chlorine-activated silica are employed as coagulants. Water temperature of the Fox River, the source of supply, varies from 33°F in the winter to about 85°F during the summer. Algae grow proliferously in the water during the June–September period.

Approximately 7 miles above Appleton, the city of Neenah, which also secures its supply from the Fox River, softens the water in a conventional plant. Because the raw water and the chemical treatment are identical, a comparison can be made between the results obtained in the suspended-solids softeners at Appleton and the conventional softener at Neenah. Use of the former units results in an appreciable saving in lime—estimated at 22 per cent for 1953—because the chemical reaction between the lime and the bicarbonates of calcium and magnesium in the presence of alum is rapid and complete. Low alkalinities were produced when water was run during summer conditions through the upflow basins at rates as high as twice the rated capacity. Moreover, alkalinity tests made at various points and depths in the two basins during periods of low flow and low temperature showed that uniform mixing and rapid reaction were taking place. Water wasted in the withdrawal of sludge varies in amount from 0.33 per cent to 1 per cent of the volume of water treated.

Solids Carryover

Although softening reactions are satisfactory at Appleton, the carryover of solids from the basins is excessive at rates beyond 2 gpm per square foot of surface area, or 53,000 gpd per foot of weir periphery. Some floc carries over the weir during periods of cold water at rates of 1 gpm per square foot of area, or 20,000 gpd per foot of weir periphery. This carryover is especially noticeable when the volume of water put through the basins is suddenly increased. From the suspended-solids units the water flows to a conventional settling basin in which it can be further coagulated if necessary, and the settlable solids can be removed.

At times, the effluent from the suspended-solids contact softeners contains turbidity in the form of disintegrated algae, fine activated carbon, col-

loidal calcium carbonate, and other finely divided material, which is not entirely removed by the calcium carbonate–coated filter sand. When such material is colored, it causes consumer complaints by staining fabrics rinsed in spray-type automatic washers. This trouble is much more severe when the water is processed in suspended-solids contact softeners than when water of the same quality is treated in conventional basins. When excessive amounts of algae are present and high dosages of carbon are in use, it appears that some light, fine, and unfilterable material escapes from the slurry zone through the sludge agitation and the upward flow of water.

Sludge Recirculation

Recirculation of odorous sludge in conventional plants has been found impractical as such material increases the odor. Because of the continuous removal of solids as they are formed, sludge in the slurry zone of the suspended-solids contact softeners which treat a supply containing odor-producing organic matter does not become as strong in odor as sludge which has been piled up for a long time. Despite almost unlimited use of activated carbon, however, suspended-solids contact softeners permit some odor to escape the slurry zone when the water is warm and the sludge contains large concentrations of organic matter. As the amount of odor is quite low (2–3 threshold odor), it may or may not be objectionable, depending on its type. On the other hand, odor can be reduced with less carbon per threshold unit through the use of suspended-solids contact basins in place of the conventional basins when there is no organic decomposition taking place in the sludge zone.

Sludge deposited in piles because of poor basin design or sludge raised from the bottom of a suspended-solids contact unit after a prolonged cessation of treatment causes strong, repulsive tastes and odors in the water when the sludge contains decomposing organic matter. At Appleton the softeners are operated continuously, except in emergencies. In case of an imminent shutdown, as much sludge as possible is withdrawn from the unit while the agitators are still running. When the basin is put back into operation, the effluent is checked for odors if the unit has not been cleaned during its idleness. Scrapers or other means of positive and continuous removal of sludge should be provided whenever suspended-solids contact basins are treating water which contains organic materials or other odor-producing substances.

It has been determined that the Appleton plant may be operated more satisfactorily by the conventional system than by the suspended-solids contact process when the supply has high concentrations of decomposing algae and receives high dosages of carbon. During periods of low algae content and little or no carbon dosage, the suspended-solids contact softeners may be used advantageously. An addition has been designed so that the plant may be operated either on the conventional or the suspended-solids contact principle.

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Use of Chlorine Dioxide for Algae Control at Philadelphia

Walter C. Ringer and Sylvester J. Campbell

A paper presented on May 5, 1955, at the Pennsylvania Section Meeting, Pittsburgh, Pa., by Walter C. Ringer, Supervisor of Labs., and Sylvester J. Campbell, Chief Chemist, Torresdale Lab., both from Water Dept., Philadelphia, Pa.

TWO basins, the North and the South, form Philadelphia's Oak Lane Reservoir (Fig. 1). Each holds approximately 35 mil gal when filled to capacity (20.5-ft depth). The basins are interconnected by two 36-in. pipes with valve controls in the dividing wall. Although the average annual discharge from the reservoir is only 3.0 mgd, on a warm day the demand may reach a peak of 30.0 mgd. The storage units supply both a gravity section of the distribution system and a high-service pumping station located beside the reservoir. Before June 1951, the basins floated on the gravity section of the distribution system, with their water levels varying with the pressure of the distribution system. The districts served by the reservoir are almost wholly residential.

The algal growths that were usually present during the summer months were controlled with surface applications of copper sulfate. In 1949 the basins received a total of 1,550 lb of copper sulfate in two treatments. The average algal count for the season was 444 standard areal units (sau).

Phosphate Addition

Water from the Delaware River comes to the reservoir from the Torresdale Filtration Plant. This supply, which clarifies best at a pH of about 6.5, is relatively soft and slightly corrosive, characteristics that give rise to numerous complaints from the area served by the plant. These complaints were reduced about 80–90 per cent by a treatment with sodium hexametaphosphate, first applied in May 1950. Presence of these phosphates affected the growth of algae in the open Oak Lane Reservoir. The extent of the aquatic-organism increase may be roughly indicated by the quantity of copper sulfate it was necessary to employ. In 1950, the North Basin was treated 14 times and the South Basin 18 times, using a total of 28,000 lb of copper sulfate. The average dosage was 1.36 ppm, as copper, based on the total quantity of water in the reservoir. The water could hardly be called satisfactory, as it had a low count of approximately 900 sau and a high of 10,808 during the season.

As the algal conditions at Oak Lane Reservoir grew intolerable in June 1951, the use of phosphate was suspended at the Torresdale Plant. By the middle of May, the count in the North Basin was 5,043 sau, with the

count in the South Basin a staggering 16,824. Although surface applications of 600 lb of copper sulfate were made in each basin, the counts remained above 3,000 and 4,000 in the basins, respectively. Increasing both the quantity of copper and the frequency of treatment did very little to bring the water to a satisfactory condition.

Other factors then entered the picture. It became possible to direct a flow through the basins after the installation of 48-in. valves at the outlets. After 10 PM, the gate to the North Basin was closed and the gate to the South Basin opened, permitting the water to flow into the latter during the period of low demand. At 6 AM, the gates were reversed, so that the water was discharged into distribution from the North Basin.

Fig. 1. Oak Lane Reservoir

This view shows the South Basin. The building at the left is used for chlorine dioxide generation.

Copper Sulfate Feeder

A solution feeder for the copper sulfate was placed at the gate of the South Basin in order to apply the copper to the water as it entered the basins during the night. This treatment was started in the middle of June and continued to the end of the year. It became standard procedure to feed 100 lb of copper sulfate to the water as it entered the basin from Monday through Friday and 200 lb over the weekend, a time when the basins normally regained the elevation lost during the weekdays. This method, along with heavy surface applications, brought the algal counts down considerably. No surface applications were made from mid-July to late September, when counts in the vicinity of 5,000 made them again necessary. The counts then dropped to less than 200 and remained in the vicinity of 10 throughout November and December, at which time all treatment was stopped.

In 1951, 59,400 lb of copper sulfate was used thus: surface application to

the North Basin, 17,200 lb; surface application to the South Basin, 13,400 lb; and solution feed to the South Basin, 28,800 lb. The total cost, including labor, was about $8,000–9,000.

Use of Chlorine Dioxide

At the Torresdale laboratory, experiments with chlorine dioxide were performed in an attempt to eliminate the phenolic tastes and odors present in Delaware River water. The researchers were interested in determining what changes the chlorine dioxide made in the benzene ring—for which it had a definite affinity—to render it tasteless and odorless. As the pyrrole rings of chlorophyll closely resemble the benzene rings, it was wondered if the affinity of the chlorine dioxide for the benzene ring might be duplicated by the pyrrole ring. If the chlorine dioxide would oxidize the chlorophyll, plant metabolism could not be carried on, for protein synthesis is interrupted and plant cells are damaged to the point where loss of water from the protoplasm brings about hypertonic shrinkage (Fig. 2 and 3). This latter process, called plasmolysis, is irreversible, causing the plant to die. Such chemical treatment proved effective in concentrations of algae as high as 180,000 per milliliter. The process not only destroyed the organisms (see Fig. 4), but also seemed to render tasteless and odorless their essential oils.

Treatment in 1952

In 1952, treatment with copper sulfate in the South Basin was started before an increase in algal growth was evident, using the solution feeder in the same manner and with the same dosages employed the previous year. Because the count started to rise in the North Basin on May 1, the chemical quantity was doubled in order to get better copper carryover from the other basin. This procedure produced the desired drop in algal counts, but as the copper carryover to the effluent of the North Basin reached 1.5 ppm, as copper, an amount considered too large, the former dosage was restored. Experimental chlorine dioxide generators were installed on each of the basins, and when the counts started to rise early in June, chlorine dioxide was applied to the water entering the South Basin during the night. This method caused a desirable reaction in that basin, but as counts in the other one continued to remain high, it was decided to apply chlorine dioxide also to the water passing through the division wall from the South to the North Basin.

At this point, the flows in the basins were reversed in order to feed the better water of the South Basin to the distribution system, necessitating the shutdown of the copper sulfate feeder. For the ensuing 4 weeks, the water remained clear and colorless in both units. In the latter part of August, the chlorine dioxide treatment of the South Basin was stopped and that of the North Basin sharply reduced. The counts rose, but not significantly until the end of September when treatment of the North Basin also ceased. As the counts then increased in both basins to several thousands, it was necessary to resume treatment and continue it to the latter part of October in both basins. Direction of flow was restored to normal on Nov. 18.

Treatment in 1953

In 1953, the copper sulfate feeder was used continuously at its most satis-

factory dosage (100 lb daily Monday through Friday, 200 lb daily Saturday and Sunday) from Mar. 9 until Nov. 22. During this year, a revealing study was made of the copper present in the water. Of the 67 tests made throughout the season, 44 had the copper analysis made before and after filtration through Whatman No. 42 filter paper. In only seven of the determinations in which the copper content was in excess of or equal to 0.5 ppm, as copper, did the filtered sample contain 50 per cent or more of the amount of copper present in the unfiltered sample. It is still not known whether the copper had formed insoluble compounds with other elements in the water or had been absorbed by the algae. It is apparent, however, that the amount of copper actually available cannot be determined when the analysis is made on an unfiltered sample.

When algal counts started to rise in mid-April, chlorine dioxide treatment was started on the North Basin. After the resulting sharp drop in the counts, the dosage was reduced until a steady rise in algae content made it necessary to increase the chlorine dioxide again. When algal counts on the North Basin reached 5,000 in the first half of July, it was decided not only to intensify the chlorine dioxide treatment in that section of the reservoir, but also to start it in the other. A clear and colorless water was produced in both sections until the North Basin dosage was halved and treatment with chlorine dioxide was stopped entirely in the South Basin.

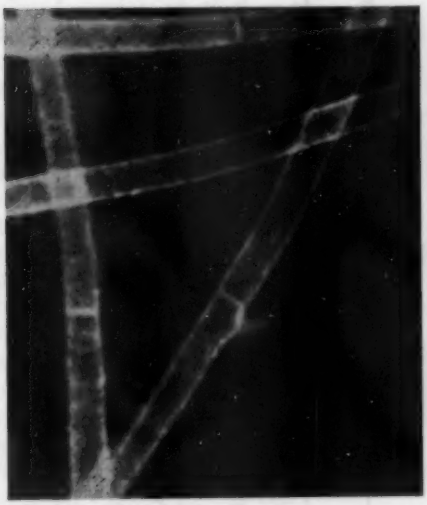

Fig. 2. Normal Plant Cells

Cladophora *depicted in this microphotograph is in a normal state.*

Fig. 3. Plasmolyzed Plant Cells

The cell walls of the Cladophora *are ruptured and internal shrinkage has taken place.*

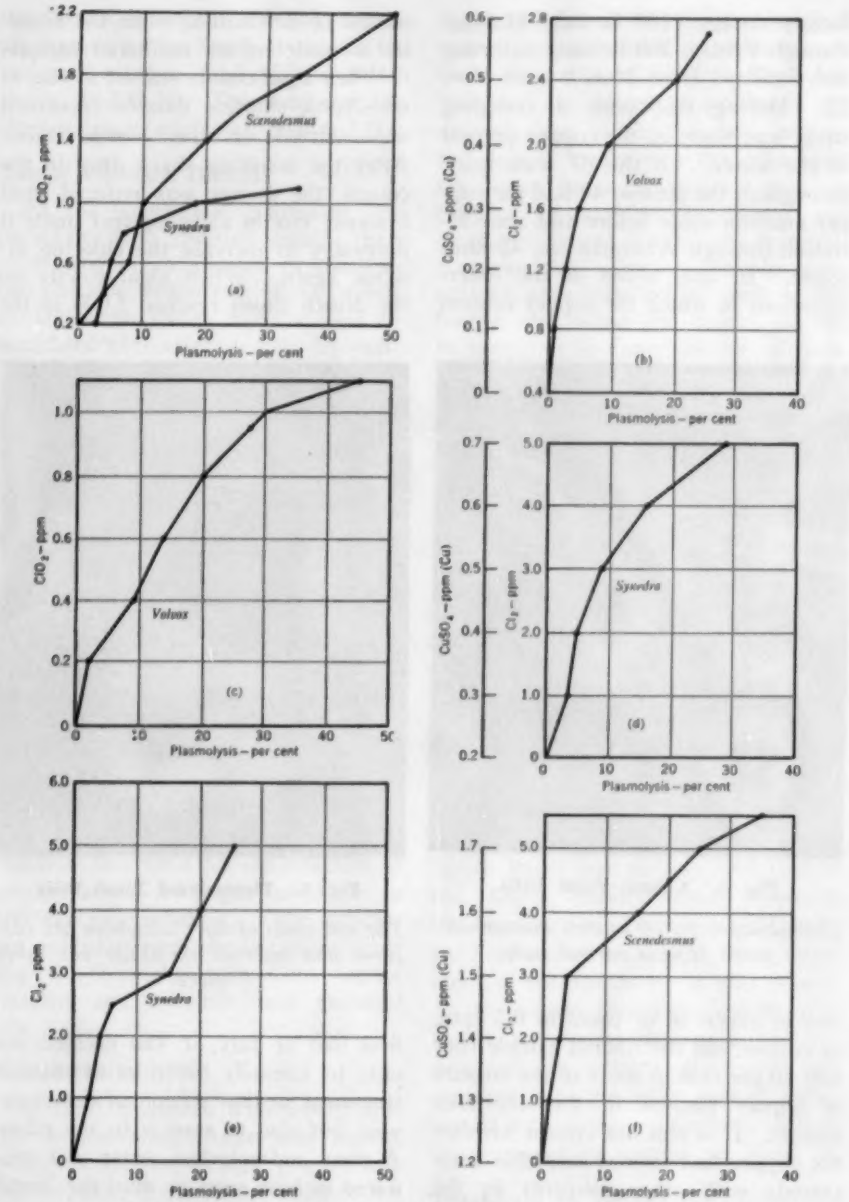

Fig. 4. Plasmolytic Effect of Chemicals in Presence of Phosphates

Contact period: (*a*) Synedra, *10 hr;* Scenedesmus, *12 hr;* (*b*) *48 hr;* (*c*) *48 hr;* (*d*) *48 hr;* (*e*) *48 hr;* (*f*) *42 hr.*

Thereafter, there was a slight rise in the North Basin counts, and in the South Basin—although it was still being treated with copper sulfate—counts rose to 2,560 sau. Because this water was not going into distribution, treatment with chlorine was not resumed. Chlorine dioxide treatment was stopped on the North Basin in mid-November.

Treatment in 1954

In 1954, chemical treatment for algae control was started in both basins on May 3. Both chlorine dioxide and copper sulfate were applied to the South Basin, but use of the latter chemical was discontinued on May 27 and not started again for the balance of the season. Thus, chlorine dioxide was used exclusively for controlling the aquatic organisms. On only one occasion, in mid-September, did the count reach 100 sau. Usually, it was 10 or less, and frequently zero; therefore, it became necessary to use a different laboratory procedure. After making a standard count which resulted in a zero reading, the laboratory technicians would record what organisms they could find by sweeping over the entire counting cell.

The characteristic sudden increase of algae which seems to result when treatment is stopped prematurely manifested itself in early October. It had been felt that the algae season should be over and all treatment could be safely stopped. This course resulted in a spectacular algal bloom in which the North Basin count reached 7,068 sau. It was necessary to resume chemical application until mid-November, at which time cessation of treatment produced no unsatisfactory effects.

Conclusion

The studies undertaken in Philadelphia show that chlorine dioxide is a more effective algicide than copper sulfate and has the advantage of not introducing a detrimental element, such as copper, into the finished water. Moreover, tastes and odors from the essential oils associated with algal growths are eliminated.

In choosing one treatment process in preference to another, their respective costs must be considered. At Philadelphia, the costs may well be charged against corrosion control. Although Oak Lane Reservoir discharges only an annual average of 3.0 mgd to the distribution system, if algae difficulties could not be treated satisfactorily in the presence of phosphate, corrosion control would have to be suspended on the entire Torresdale supply, which provides an annual average of 182 mgd, 49 per cent of the total supply.

For comparison of actual costs, a suitable example is provided by the year 1951, in which copper sulfate was used in concentrations as high as good practice permitted. In that year, the surface application and the solution feeder used 59,400 lb of copper at $0.12 per pound, a cost of $7,128. Labor for the surface application required four men for 24 days at $12 per day, or an additional $1,152. Thus, a total of $8,280 was spent for the season.

In 1954, the year the maximum amount of chlorine dioxide was used, a total of 18,225 lb of chlorite at $0.59 a pound and 75,706 lb of chlorine at $0.053 a pound were used at a total cost of $14,765.17. Thus, in 1951

$8,280 was spent for very poor control, while in 1954 $14,765 was expended for very good control. The extra cost for the chlorine dioxide treatment may well be considered offset by the difference in the quality of the finished waters. The public demands and has the right to expect water of as high quality as modern technology permits.

EDITOR'S NOTE: Graphs showing day-to-day conditions at the reservoir during the study were technically not suitable for publication. Copies of these charts may be secured by any interested AWWA member. Requests should be addressed to Walter C. Ringer, Supervisor of Labs., Water Dept., City Hall Annex, Philadelphia 7, Pa.

Waterborne Disease Outbreaks in 1954

The June 1955 issue of *Public Health Reports* carries an article by C. C. Dauer and Granville Sylvester, of the US Public Health Service, entitled "1954 Summary of Disease Outbreaks." With regard to waterborne disease outbreaks, the article states:

> In 1954, only four outbreaks were reported in which there was good evidence that water was the vehicle of infection. There were also three other outbreaks in which water was suspected as the source of infection.
>
> One of the four waterborne outbreaks was typhoid fever in a coal mining village where water was pumped from a worked-out section of a mine into the distributing system of the town. Two outbreaks of gastroenteritis were reported. One was explosive and followed contamination of the water supply after heavy rains; the other occurred in a recreational area where untreated well water was used.
>
> Other outbreaks suspected of being waterborne included three of gastroenteritis following consumption of water of doubtful sanitary quality.

All of these outbreaks of disease occurred in small nonmunicipal water systems. Such sources are likely to receive the minimum of attention by public health engineers, as well as by the owners.

Short-School Program in Oregon

Fred J. Burgess

A contribution to the Journal by Fred J. Burgess, Assoc. San. Engr., Director, Short-School Program, Oregon State College, Corvallis, Ore.

SHORT schools and other forms of adult education for water works operators are certainly not new. In fact, the history of such schools is at least 30 years old. Oregon's program has come about in much the same manner as those in other states. The organization is somewhat different, however, and, thus, of interest. During 1949–53, two short schools were held annually. One was for county sanitarians and the other for water works operators. The schools were conducted by Oregon State College, Corvallis, Ore., and the State Board of Health. The labor necessary for the planning, organization, promotion, and operation was drawn from the regular staff members. By fall 1953, these people were unable to handle the work load because of additional demands. These included:

1. The need for a short-school setup for sewage works operators, necessitated by the remarkable success of the State Sanitary Authority's water pollution abatement program, responsible for the construction of 65 new or improved sewage treatment plants.

2. An urgent request by city engineers for a short-course program to cover new engineering methods, construction materials, building codes, and new developments in water supply and sewage treatment.

3. Requests by industrial management for a training program on detection and treatment of atmospheric contaminants.

4. The start of a water works operators certification program, to be operated in conjunction with the short-school program.

5. The need for a sewage works operators certification program.

Organization

In order to facilitate the operation of required short-school programs, Oregon State College and the State Board of Health entered into an agreement in September 1953 to share the expenses of a full time sanitary engineer, whose duties would be to direct and coordinate the programs in addition to carrying a half-time teaching load in the college's Dept. of Civil Engineering.

The short courses now in operation include those held for water works operators, sewage works operators, and county sanitarians. In addition, the water works operators certification program and the water works operators regional conference program are also in active operation.

In each of the individual programs, an advisory committee of operators has been appointed to assist in planning and guidance. Wherever possible, the committee appointments are made through the cooperation of the association or society that officially represents each occupational group.

For instance, the Water Works Advisory Committee was appointed with the help of the Pacific Northwest Section of AWWA. This arrangement has been found to be very satisfactory in that it gives the operators an opportunity to take an active part in planning their own program.

Administration

Each person attending a short school is officially registered at the college, with the attendance made a part of its permanent records. The registration fee for a 3-day course has usually been set at $4.00. This sum is sufficient to pay for the supplies, printing, and other goods connected with the school. The materials generally distributed consist of the advance notices, a three-ring looseleaf notebook, a complete set of lecture notes (given out at the time of registration), a lapel badge, pencils, and extra note paper. Some special items are occasionally given out. For instance, when one session was on the use of a slide rule, an inexpensive, but serviceable one was given to each pupil. Technical bulletins and data furnished by manufacturers are included in the short-school notebook wherever appropriate, having been found to be a great aid.

No attempt is made to pay secretarial help or the salary of the director through registration fees. Both agencies involved feel that the short schools are a legitimate and necessary function. As such, the labor costs are justified as a regular part of budgeted activities and should not be borne by the operators.

The short schools are usually conducted during a 3-day period because 8 hr a day of classroom or laboratory work for three days in succession is the usual limit of endurance. Whenever possible, a short field trip is scheduled, to aid in instruction and provide a rest from classroom routine.

Objectives

The overall objectives of the short-school programs are to provide specialized training wherever it is needed. The main objectives are:

1. To make every effort possible to give instruction that will help facilitate a reduction of the hazards to public health incident to the operation of the various types of utilities covered by the programs.

2. To improve the general level of knowledge and efficiency in the various occupational groups covered by the short courses.

3. To stimulate a desire for self-improvement in order to extend the academic interests of the operators beyond the short-school classroom and into their everyday activities.

In connection with the third objective, every effort is made to encourage the operator to belong to the official association or society representing his occupation and to take an active interest in research, recent developments, and new equipment. The complete process of training cannot be accomplished in the brief period of time given to short courses. These are primarily for the purpose of instructing the operator in specialized techniques and new methods, which must be mastered individually.

Short History of Filter Construction and Operation

G. R. Scott

A paper presented on Oct. 6, 1954, at the Minnesota Section Meeting, St. Paul, Minn., by G. R. Scott, Engr., Black & Veatch, Kansas City, Mo.

A HISTORY of the construction and operation of filters should coordinate their function with that of the other units in a treatment plant and outline the amount of dependence on filters during the development of the treatment processes.

Household and industrial filters were in use prior to 1804, but the first plant to furnish filtered water to an entire community was built in that year by John Gibb to supply water to his bleachery and the people of Paisley, Scotland. Nevertheless, it is generally considered that filtration for domestic purposes began in 1829 with the construction of slow sand filters by James Simpson for the Chelsea Water Co., London.

The early filters were employed merely to remove turbidity by simple straining, but it was soon found that they operated better after having been in service for a time and after organic matter had accumulated on their surfaces. Analysis of the various forms of nitrogen in the water indicated that this element was being oxidized in its pasasage through a satisfactorily operating filter bed, but it was not demonstrated that filters also removed bacteria until Frankland in 1886 used the new bacteriological techniques of Robert Koch. It was found that the organic matter in the beds consisted of bacterial growths which were responsible for the oxidation phenomena and the removal of bacteria. Through serendipity, therefore, a process had been developed which removed pathogenic organisms before science had discovered that diseases could be transmitted by the bacteria in water. During the early period of water treatment, the filter was the only barricade preventing harmful organisms from reaching the consumer.

Early US Filters

The first successful slow sand filter in the United States was built at Poughkeepsie, N.Y., in 1872. The first mechanical or rapid sand filter was built in Somerville, N.J., in 1882 under the Hyatt patent. To the raw water was added a coagulant that formed a mat on the filter surface to serve as a substitute for the bacterial growth of slow sand filters. Because the accumulation of coagulant and retained solids rapidly caused severe loss of head, it was necessary to clean the sand at frequent intervals. This was done by reversing the flow through the bed and disposing of the dirty water. The slow sand filters required cleaning at

less frequent intervals, and this was usually done by removing the top layer of material holding the bacterial growths and retained solids. As rapid sand filters became the more popular in the United States in the early 1880's, a number of patents were issued covering differences in design, primarily in the manner of introducing wash water and accomplishing sand agitation.

These filters operated satisfactorily on supplies not highly turbid, but failed at New Orleans in 1893 when tried on Mississippi River water. Tests were carried out in Louisville between 1895 and 1897, under the supervision of George W. Fuller, in which four patented installations treated water from the Ohio River. He concluded that extremely turbid waters required plain sedimentation, coagulation and sedimentation, and then the addition of a coagulant before being passed to the filter. Later experiences at Louisville, Cincinnati, and elsewhere had by 1907 established an average rate of 125 mgd or 2 gpm per square foot of filter area as the best.

Modern Developments

During the past 50 years the art of coagulation and sedimentation has changed to a science, and chlorination has become synonymous with disinfection. Yet, it is still found difficult to depart from the flow rate that was established half a century ago. Table 1 presents a few statistics comparing conditions of 1900 with those of 1950. The data present the increase in the use of filtered water and the decrease in mortality from typhoid and other enteric diseases. It should not be assumed that the reduction in death rates is attributable entirely to more extensive use of filtered water. The mortality figures illustrate the combined effect of the following public health measures, all of which were adopted within the 1900–50 period: [1] improvements in water treatment, including, first, postchlorination and, later, prechlorination; [2] immunization by vaccination; [3] widespread sewage disposal and treatment; [4] milk pasteurization; [5] shellfish control; [6] sanitation of food handling; [7] rural sanitation; and [8] health education.

Along with the development of the knowledge about enteric diseases—their modes of transmission and methods of control—has come a new con-

TABLE 1

Comparison of 1900 with 1950

Item	1900	1950
Total population	76,000,000	150,700,000
Population using filtered water	1,860,000	46,500,000
Deaths from typhoid	more than 23,000	114
Deaths from all other enteric diseases	more than 100,000	1,183

cept of the function of filters. They are no longer the sole protection from disease, but have been relegated in modern plants to the less important role of polishing the effluent of the carefully controlled pretreatment processes of mixing, coagulation, and sedimentation. Although some bacteria removal takes place in the filter bed, the major portion is accomplished by sedimentation, with chlorination relied upon for satisfactory disinfection. Today's improved methods permit rates of filtration exceeding 2 gpm per square foot. After 5 years of using filter rates as high as 5 gpm per square foot on Lake Michigan water, Baylis (*1*) concludes that when water is prop-

erly conditioned, it can be safely filtered at average rates reaching 4 gpm per square foot. As the acceptance of higher rates will result in a considerable savings in the cost of filter plants, this is now being considered in the design of many new plants being planned or under construction.

Old and New Arrangements

The underdrain system of the early filters consisted of false bottoms of wood or perforated plates, or of pipe grids with orifices or strainers. These systems removed the effluent from the bottom of the filter and (of greater importance) applied wash water at a uniform rate to all sections under the beds. The latter was not accomplished satisfactorily in the earlier filters. During the search for better methods, early types of underdrains were replaced by: [1] vitrified clay blocks containing passages for the water and surface openings for uniform application; [2] special flood construction with inverted pyramidal recesses containing spherical balls; and [3] porous plates. Where pipe grids were used, auxiliary diffuser blocks were added to improve uniformity of application.

The coarse sand and gravel bed which supported the filter sand and which was relied upon to aid in spreading the wash water, was originally about 18 in. thick, with material grading from 2½ in. at the bottom to ¼ in. and less at the top. This bed is now generally less than 12 in. thick and is made up of material smaller than ¾ in. and larger than ¼ in.

The depth of filter sand, with an effective size of 0.35 mm, in the early filters averaged 24 in., although there were units with lesser or greater amounts. The later units have sand beds generally 30 in. deep, consisting of material with an effective size ranging from 0.50 to 0.60 mm.

Along with the changes within the filters, better equipment for their operation and control has been developed. Hydraulically operated gates, displacing the unsatisfactory hand-operated valves, are now giving way to motor-operated units. Some of the newer installations have control panels which, after having started, automatically carry out the sequence of washing operations from taking the filter out of service to placing it back in operation. Rate controllers and indicating and recording equipment can now be depended upon for reliable information. Larger filter piping is being provided for the higher rates of filtration and wash water now used.

The application of inadequately pretreated water to the early filters resulted in accumulation of retained material, forming mudballs and resulting in cracks through which water passed to the underdrains without filtration. The early rates of wash water application ranged from 7.5 to 10 gpm per square foot. Agitation during the operation was by mechanical means in some filters and by the use of compressed air in others. These methods soon lost favor, and the rate of wash water was increased to 15 gpm per square foot and, later, to as high as 19 gpm per square foot in the summer when the water is warm and the viscosity is low. In some instances, additional water is applied to the bed surface in jets of relatively high pressure to improve washing operations. These changes were expedients to remove the material carried to the filters

by the water from the pretreatment processes. The best solution to the problem was to improve the pretreatment processes so that less material would be carried over to the filters.

Today the chemistry of coagulation and the hydraulics of sedimentation are better understood; equipment is available which satisfactorily and accurately feeds chemicals to the water; mixing, coagulation, and sedimentation facilities are being designed only after a thorough study of the water supply; the operation of each treatment unit is under closer supervision than formerly; and chemical tests are routinely made to obtain information that serves as a guide in the adjustment of chemical dosage.

The early opinion that some flocculant material should be allowed to reach the filters in order in obtain efficient operation was seriously questioned by Hulbert and Herring in 1929. By 1935 it was fairily well established that a clean sand is desirable and that coated sand grains are not essential for good operation. Greater care has since been exercised to minimize the amount of floc and turbidity going to the filters. Previously, 25 ppm or more of turbidity was considered suitable, but now 10 ppm or less is usual in many plants. Chlorine is added at some step in the pretreatment process of many installations in sufficient amounts to produce a residual in the filtered water. This practice prevents biological growths and promotes clean filter beds.

The amount of water required for washing the early beds averaged about 5 per cent of the amount filtered, although, at times, a much larger quantity was required. In some plants, washing was necessary five or six times a day. At the present time, the amount of wash water may not average more than 2 per cent, while filter runs have been increased measurably. The sand bed is usually in excellent condition and mudballs are uncommon. Best of all, the water quality has been improved.

Summary

This paper has presented a rather brief sketch of the development of water filtration practices. It has been shown that the goal always has been better water: first, water free of turbidity; and later, water free of pathogenic organisms. Furnishing a better product should continue to be the objective of utilities. The design and operation of filters have been changed as science has uncovered information on which to plan improvements. This progress should continue in the future. Although the goal is fixed, the method should be sufficiently flexible to permit the utilization of new ways and materials so that science—through engineering application—can continue to improve on the construction and operation of filters.

Reference

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Effect of Disinfection Dosages of Chlorine on New Mains

William Yegen

A paper presented on Jun. 13, 1955, at the Annual Conference, Chicago, Ill., by William Yegen, Supt., Filtration Plant, Bismarck, N.D.

DURING the 28 years prior to the end of 1952, there had been only about six to eight complaints of red water per year in Bismarck, N.D. The first of a long series of such complaints, which at times reached as many as six to eight per day, occurred on Dec. 20, 1952. Samples collected by the author showed that both the cold water and the hot contained 20 ppm iron.

The second complaint came on Jan. 29, 1953, from the far end of the city. The iron content at that point was 1.2 ppm in both the cold water and the hot water. The fact that the cold water was a source of trouble as well as the hot made the problem seem different from previous red-water difficulties. Another complaint on Mar. 27, 1953, showed 3.5 ppm iron in the cold water. A series of city-wide tests was carried out by the author in cooperation with the State Health Dept.

Six widely separated points checked on July 3rd indicated stable water, for there was little change in alkalinities, pH, and hardness from the water as it left the plant. During June, a pH of saturation of 9.2 (Langlier Index 0.65) was carried, a reading which usually indicates a stable water. The critical period for stability is during the winter months, when such extremes of temperature as 32°F in mains and 140°–160°F in the hot-water heaters must be considered.

Two dead-end mains sampled on July 3rd showed iron present in the considerable amounts of 0.58 ppm and 1.31 ppm (Locations 1 and 2 in Table 1). Because the water sampled on that date was stable, it must be assumed that the iron was deposited sediment or had come from local corrosive action of some time past. Flushing those areas helped alleviate red-water conditions during the summer months. A control sample taken from a tap in the State Capitol building showed 0.13 ppm iron, a very low amount, which would cause no trouble.

Because oil was struck in North Dakota in the Spring of 1951, Bismarck was by 1952 confronted with a vast expansion program. The laying of new mains was out of all proportion to any such previous activity. Up to that time, mains had been disinfected by either of these methods:

1. About a tablespoonful of hypochlorite was placed in each section of a completed main, which was then filled with water and flushed out after 24 hr.

2. The main was filled with water and the amount of chlorine necessary for sterilizing the section of newly laid

main. A pump forced the solution into the main until the pressure was 150 psi, which pressure was held until the main was flushed out the next day.

TABLE 1

Iron Content at Four Locations

Location	Date	Iron *ppm*
	Jan. 29, 1953	1.2
	Oct. 6, 1953	0.7
	Oct. 13, 1953*	
	Nov. 18, 1953	0.6
1	Dec. 30, 1953	0.5
	Mar. 10, 1954	0.3
	Mar. 13, 1954†	
	Jul. 26, 1954	0.1
	Feb. 10, 1955	0.1
	Dec. 14, 1953	1.9
	Dec. 17, 1953	1.7
	Dec. 18, 1953*	
2	Jan. 18, 1954	1.8
	Jun. 9, 1954†	0.3
	Jul. 29, 1954	0.1
	Feb. 10, 1955	0.1
	Sep. 6, 1953	3.0
	Oct. 6, 1953*	2.2
	Jan. 8, 1954	0.8
3	Mar. 10, 1954‡	0.4
	Jul. 29, 1954	0.15
	Aug. 27, 1954	0.10
	Feb. 10, 1955	0.10
	Jun. 4, 1953	0.6
	Aug. 11, 1953	0.7
	Oct. 18, 1953	0.8
4	Feb. 2, 1954*	1.7
	Feb. 10, 1954	1.5
	Mar. 10, 1955	0.4

* Meter removed from last house on main.
† Meter replaced.
‡ A new extension of cement-lined pipe was made.

When these methods were used on one or two blocks of main, no appreciable amount of trouble was encountered. In areas where ten to twenty blocks of main were laid at one time, however, it was necessary to use improved procedures. The utility engineering department was directed by the state sanitary engineer to use 100 ppm residual chlorine in all newly laid mains for at least 24 hr.*

The first indication that the red-water troubles might be attributed to something other than the usual reasons came in August 1953, when the author was called to investigate a taste complaint (Location 3 in Table 1). It was found that a chlorine odor could be detected even when a glass of water was held 2 ft away from the nose. It was found that one block of main had been added on the street where the trouble existed and that disinfection had taken place 4 days previously. The main was flushed, ending the problem.

Cement-Lined Pipe

On Sep. 6, the author went back to the same location to investigate a complaint of red water. Upon examination it was found that the cold water contained 3 ppm iron, although the plant effluent had only 0.1 ppm iron. On two nearby streets with recently laid mains there were no red-water difficulties, although there was a slight rise in the iron content of the water to 0.45 ppm on Oct. 9, 1953. It was decided to substitute cement-lined pipes (the same price as tar-lined) on all new construction and cut the disin-

* If the circumstances are such that a shorter retention period must be used, the chlorine concentration must be increased accordingly. For instance, for a contact period of 1 hr, a 100-ppm chlorine concentration is required. Under these conditions, special care should be taken to avoid attack on pipes, valves, hydrants, and other appurtenances (*1*).

fection dosage to 50 ppm chlorine or less, maintaining contact for not more than 1 hr. On Dec. 11, samples of water were collected from all dead ends on the old system. This survey indicated that the troubles were all located in new mains. The iron content of all old dead ends was negligible, only one reaching as much as 0.2 ppm iron.

In September 1953, after a large main-laying job was completed, a disinfection solution of 100 ppm chlorine was kept in the pipe about 6 hr. The area of this project has been a source of a number of red-water complaints. Some cement-lined pipe laid in the same section has been free of excess iron.

Two blocks of tar-lined pipe (Location 4 in Table 1) which was disinfected with 100 ppm chlorine over a 45-min contact period showed iron pickup of sufficient magnitude to cause trouble.

The iron content of the water at this location, as shown in Table 1, indicates that tar-lined pipes sterilized with 100 ppm chlorine will be damaged in as short a contact time as 45 min.

In summer 1954 twenty blocks of newly laid cement-lined pipe was disinfected with 50 ppm chlorine for 45 min. No iron pickup was observed in this area. It is anticipated that the red-water difficulties will end as soon as the mains laid back in the early part of 1953 have stabilized themselves. In order to alleviate the trouble in places where there still is some deterioration, the hydrants at the end of these lines are periodically flushed. In addition, the meter is taken off the last house on each main and the homeowner is encouraged to run enough water to keep it free of iron.

Where chlorine residuals of 100 ppm are held in tar-lined pipes for 45

Fig. 1. Damaged Pipe Coating

This specimen was taken from Location 1 (see Table 1). The pipe had been exposed to 100 ppm chlorine for 24 hr, resulting in about 20 per cent damage to the tar coating.

Fig. 2. Severely Damaged Pipe Coating

Taken from Location 2 (Table 1), this specimen was from pipe exposed to 100 ppm chlorine for about 10 days. The tar coating was about 80 per cent damaged.

min or more, there will be some damage to the lining (see Fig. 1 and 2), resulting in complaints about red water. The use of 50 ppm residual chlorine for a contact of 1 hr in cement-lined pipe will avoid iron pickup.

If mains are laid according to AWWA specifications, it should not be necessary to use more than 10 ppm residual chlorine. It is felt that all of the red-water troubles in the last 3 years was caused by the oxidation of tar coating by the excessive use of chlorine solutions in the disinfection process.

Reference

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Utilization of Waste Pickling Acid in Potable Water Treatment

J. S. Gettrust

A paper presented on May 5, 1955, at the Pennsylvania Section Meeting, Pittsburgh, Pa., by J. S. Gettrust, Supt., Water Purif. & Pumping, Bureau of Water Supply, Akron, Ohio.

THE first use of iron sulfate as a coagulant was at Quincy, Ill., in 1903. A little later the chemical was used at Vicksburg, Miss., and Lorain, Ohio. In 1916 a text (*1*), explaining the use of iron sulfate for clarification and purification, made this statement: "Use enough lime to absorb all of the free and a small portion of the semicombined carbonic acid and enough iron to produce a satisfactory coagulation. This one rule, properly applied, contains the secret of successful operation and will meet any and all possible conditions which may arise with any supply to which the process can be successfully applied." The method of using ferrous sulfate so described is the old lime and iron process, in which the ferrous sulfate ($4FeSO_4$) is changed to ferrous hydroxide ($Fe(OH)_2$) by the addition of lime and then the ferrous hydroxide is oxidized to ferric hydroxide by the natural oxygen in the water:

$$4Fe(OH)_2 + O_2 + 2H_2O \rightleftarrows 2Fe_2(OH)_6.$$

The filtration plant completed in 1915 at Akron was designed to use aluminum sulfate as the coagulant. The water supply is obtained by impounding the Cuyahoga River, whose color varies from 20 ppm to 60 ppm, averaging about 32 ppm. Akron first became interested in the use of ferrous sulfate, commonly known as pickling liquor, in 1935, when it was found that a supply was available about 5 miles from the filtration plant in a factory that makes bolts, nuts, and cotter pins from steel wire (*2*). The wire is cleaned of scale and rust by dipping it in hot sulfuric acid and then rinsing away the acid. When exhausted, the acid contains a little over 4 lb per gallon of iron sulfate ($FeSO_4 \cdot 7H_2O$) and 1–2 per cent of free acid, and weighs about 10 lb per gallon.

The rinse water is collected in the same vat that receives the spent acid, reducing the strength of the pickling liquor to about 3 lb of ferrous sulfate per gallon, about the average strength of the pickling liquor delivered to the Akron filtration plant. The liquid is transported in a 1,000-gal wooden tank mounted on a truck (Fig. 1). At the plant, the liquor flows by gravity into a 12,000-gal storage tank in the basement of the chemical building. The container, rectangular and built of reinforced concrete lined with acid-proof brick, is equipped with a depth gage to show the height of the fluid.

The outlet at the base of the tank connects, by means of an acid-proof hose, with a chemical-feed machine which has a capacity of 3.33 gpm (Fig. 2).

Before the pickling liquor was first used, some laboratory tests showed that the lime and iron process gave good results. Because there was not enough pickling liquor available, aluminum sulfate was used when necessary. During the first few weeks of operation, excellent results were obtained while the color of the raw water was about 25 ppm. Then, a sudden runoff increased the color above 40 ppm. At this point, or greater, complex organic ferrous iron compounds which impart color that cannot be removed by filtration are formed. Tests made in the laboratory showed that by chlorinating the pickling liquor and using the product as the coagulant, good flocculation and color removal could be obtained. It was also found that aluminum sulfate and chlorinated copperas would work well together and that the amount of each could be raised to give the total dosage required. In other words, chlorinated copperas and aluminum sulfate could be interchanged dose for dose.

Fig. 1. Delivery of Pickling Liquor

The liquid is transported in the 1,000-gal wooden tank mounted on the truck.

Chemical Reactions

In theory, 1 lb chlorine will oxidize 7.8 lb of iron sulfate. In practice, 20 lb of chlorine per million gallons per day is mixed with each 17.12 ppm of iron, or about 1 lb of chlorine to 7.2 lb of iron sulfate. The amount of chlorine used for this purpose sometimes exceeds 1,200 lb per day. This is the theoretical reaction:

$$6FeSO_4 + 3Cl_2 = 2Fe_2(SO_4)_3 + 2FeCl_3.$$

The ferrous sulfate is oxidized to ferric sulfate, and ferric chloride is formed in the reaction. The resulting ferric compounds, called chlorinated copperas, are both coagulants which, when added to water, react with the natural bicarbonates in the water to form hydrates. This reaction is similar to the one occurring with aluminum sulfate. Ferric chloride reacts with natural alkalinity as follows:

$$2FeCl_3 + 3Ca(HCO_3)_2 = 2Fe(OH)_3 + 3CaCl_2 + 6CO_2.$$

Ferric sulfate reacts as follows with the natural alkalinity to form the desired ferric hydroxide floc:

$$Fe_2(SO_4)_3 + 3Ca(HCO_3)_2 = 2Fe(OH)_3 + 3CaSO_4 + 6CO_2.$$

Process Utilized

Because ferric floc is heavier than alum floc, it has the advantage of settling out faster. Moreover, the former is insoluble and is precipitated over a wider range of pH values than aluminum hydroxide. It is easy to chlorinate the pickling liquor by introduc-

ing it into a reaction chamber through which the discharge from a chlorinator is passing. The reaction, while fast, is not instantaneous. A number of reaction chambers was used before a 50-ft length of 3 in. two-ply rubber hose was chosen as the reaction chamber. The water from the chlorinator flows continuously through this hose. The ferrous sulfate is drawn from the feeder by an acid-proof, water-operated ejector which forces the chemical into the 3-in. hose. A small glass stopcock for sampling the chlorinated copperas is located at the discharge end of the hose. Specimens are drawn off at intervals of about every 2 hr, or whenever changes are made in the dosage, and tested, using potassium ferricyanide as the indicator to determine if the reaction is complete. A blue color indicates insufficient chlorine, while the completed reaction gives a straw-yellow color.

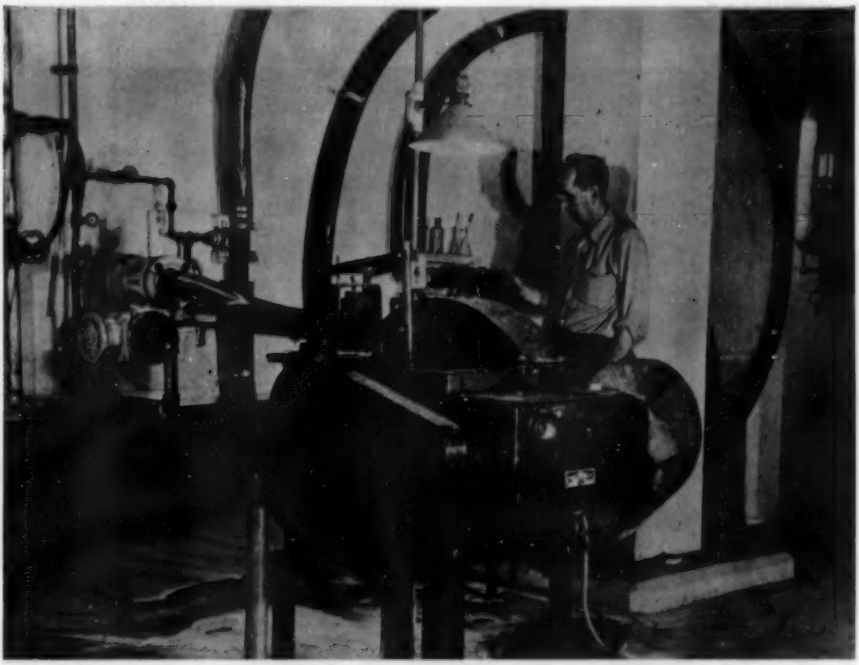

Fig. 2. Ferrous Sulfate Feeding Machine

The apparatus has a capacity of 3.33 gpm and is calibrated in gallons per minute. The 3-in. acid-proof hose seen coiled in the background is the reaction chamber for mixture of chlorine water and ferrous sulfate.

The 50-ft hose provides ample time for the reaction to be completed before the chlorinated copperas reaches the water. For prechlorination and sup-

plying the chlorine for oxidizing the ferrous sulfate, three chlorinators are used, each having a capacity of 2,000 lb of chlorine per 24 hr (see Fig. 3). The chlorine is received at the plant in 1-ton steel drums, 15 to a carload. These are taken from the car by an electric hoist, which operates on a monorail track.

to the chlorine-feed machines. The chlorinated water then goes to the 50-ft rubber hose, where the ferrous sulfate is injected. The chlorinated copperas flows through the hose to the point of application to the raw water just ahead of flash mixers. The treated water goes through flocculators and settling basins before filtration.

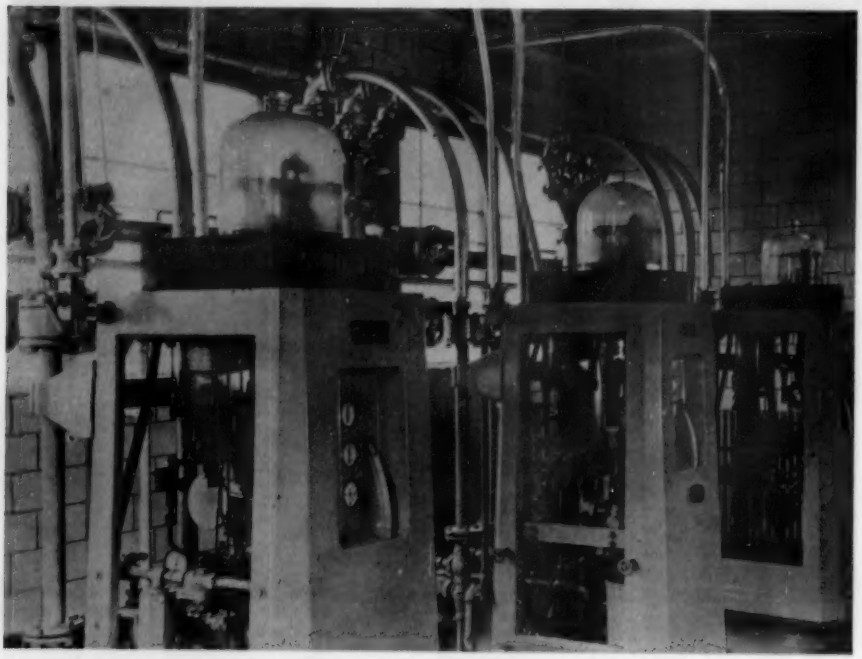

Fig. 3. Chlorinators

Each of these three machines has a capacity of 2,000 lb of chlorine per 24 hr.

For weighing the chlorine as it is used, there are two large scales with dial indicators and recording gages (Fig. 4). Three cylinders at a time are carried on each scale platform. These are connected up so that liquid chlorine flows through an evaporator

The alum is introduced into the raw water at the same place as the chlorinated copperas. Most of the time a mixture of two coagulants is used, because iron sulfate supplies are insufficient; the required dosage is made up with the alum. The average required

coagulant dose is about 32.53 ppm. Over a long period of time the average dose has consisted of 11.99 ppm chlorinated copperas with 20.54 ppm alum.

Economy of Process

The strength of the ferrous sulfate liquor received at the plant varies from 1 to 4 lb of iron sulfate per gallon, averaging about 3 lb per gallon. The strength of the liquor is determined with standard potassium permanganate in cold acid solution. The required feed of the liquor, in gallons per minute, to give the desired dosage is determined as follows: Divide the product of the rate of filtration, expressed in million gallons per day, and the dose, expressed in grains per gallon (1 gpg = 17.12 ppm), by ten times the strength of the liquor in pounds per gallon. As an example:

The iron dose is to be 0.7 gpg; the rate of filtration is 35 mgd; and the strength of the ferrous sulfate is 2.2 pounds per gallon. Then the rate of feeding the ferrous sulfate, in gallons per minute, will be:

$$\frac{35 \times 0.7}{2.2 \times 10} = 1.11 \text{ gpm}$$

Although each coagulant achieves the same result, the costs for the iron coagulant is considerably less than for the alum, roughly about one-half. Transportation costs, an important factor, vary considerably for different locations, according to their distance from point of manufacture. In round figures, the total costs at Akron are $40.00 per ton for alum and $20.00 per ton for chlorinated copperas.

The average pH of the raw water is about 7.6. Lime is added after coagulation and settling, in sufficient

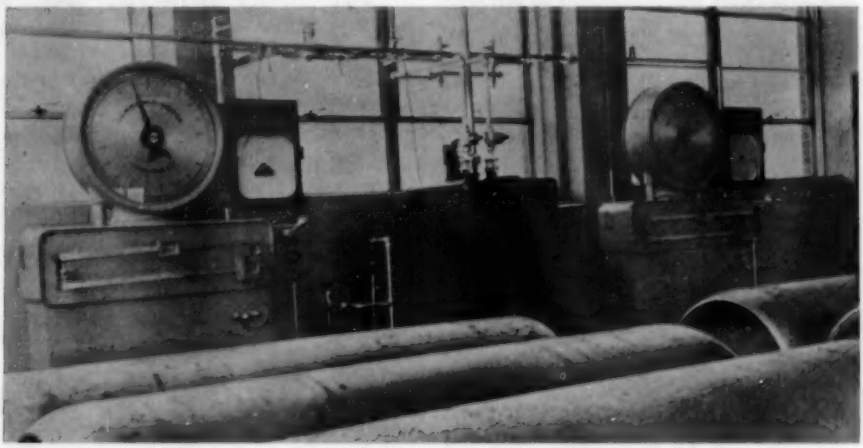

Fig. 4. Chlorine Scales

Three cylinders at a time are carried on each scale platform. As the chlorine is used, an exact record of the amount can be kept.

quantity to combine with all the free CO_2 and supply an alkalinity to phenolphthalein of 2 or 3 ppm. The free acid in the pickling liquor requires the use of additional quantities of lime. The pH reduction due to the free acid, however, aids in the alum coagulation. The pH of the finished water averages about 8.2.

The results obtained at Akron with the combination of alum and ferrous sulfate has been highly satisfactory, not only from the standpoint of effluent quality, but, also from financial considerations. From the inception of this method in 1935 to Jan. 1, 1955, the total saving has been estimated at $162,800.

References

1. *Manual of American Steel & Wire Company's Process of Water Purification With Sulfate of Iron.* American Steel & Wire Co., New York (1916).
2. GETTRUST, J. S. & HOSTETTLER, C. O. Coagulation With Ferrous Sulfate. *Jour. AWWA,* **44**:459 (May 1952).

1954 Utility Safety Record

The National Safety Council has released statistics on injury rates occurring in 1954 in 40 different industries in the United States. Again, as usual, the communications industry leads all the rest with a frequency rate of 1.30 and a severity rate of 0.13. Just how excellent these rates are may be observed from the following table which lists the rates for all the utilities.

Utility	Frequency *	Severity †
Communications	1.30	0.13
Electricity	8.62	1.52
Gas	10.51	0.69
Water	19.76	0.95
All 40 industries	7.22	0.80

* Number of lost-time injuries per 1,000,000 man-hours.
† Days lost per 1,000 man-hours.

It will be noted that the water utilities still remain among the high-hazard industries. Even so, progress is noted in the frequency rate, which dropped in one year from 23.19 to 19.76, a reduction of 14.8 per cent. The severity rate remained practically static with rates of 0.093 and 0.95 for 1953 and 1954, respectively.

Low-Temperature Problems in Alaska

Amos J. Alter

A paper presented on May 19, 1955, at the Pacific Northwest Section Meeting, Yakima, Wash., by Amos J. Alter, Chief Eng., Div. of Sanitation & Eng., Alaska Dept. of Health, Juneau, Alaska.

WATER works operators and engineers have been literally serving Alaskans water on ice. Because permanently frozen soils are sources of ground water and snow-fed streams supply surface water, low temperature often causes trouble. Alaska is the laboratory and proving ground for developing water sources and distribution systems for communities on ice-caps, icefields, and even ice islands. The steady trek of a rapidly increasing population is pushing back the frontiers of the polar regions, which are roughly six or eight times the total area of the United States. An adequate supply of safe water is a requirement, of course, in any inhabited part of the vast polar domain. Although many ingenious arrangements and devices are currently in use to provide Alaskans with water, Arctic water supply methods are just in the developmental stage.

Snow and ice melters, distillation apparatus, recirculating distribution systems, pitorifices, utilidors, supercooled water, frazil ice, and summer distribution systems are but a few of the things suggestive of Alaskan water supply gadgetry and problems. The physical, chemical, and biological properties of water at a temperature just above 32°F are considerably different than when the water is 60°F or higher. Some of the ingenious practices developed to compensate for low temperature are described in this paper.

Alaskan Conditions

These are the climatic and physical conditions experienced in Alaska:

1. Mean annual air temperatures range from a high of 45°F, in the southeastern tip of the territory, to a low of 10°F, at Point Barrow; approximate mean annual ground temperatures are only slightly higher at a depth of 8 ft.

2. Approximate minimum recorded temperatures range from 0°F along the southeastern coast to almost − 80°F in the central plateau region near the Canadian-Alaskan border.

3. The number of days yearly on which the maximum temperature is 32°F or less ranges from 20 in the southeastern coastal region to 280 at Barrow.

4. The annual total precipitation ranges from less than 5 in. at Barrow to over 200 in. in parts of southeastern Alaska.

5. Permanently frozen ground (permafrost), extending down from a few feet in southern areas to almost 1,200 ft in the northern portion of the territory, is so extensive that approximately 66 per cent of the land area may be classed in the permafrost region.

6. There are many high mountains and glaciers in the territory; runoff is flashy in the mountainous and permafrost regions, except in the flat, low portions of the central plateau and Arctic slope. Vertical drainage is

sluggish in the low, flat areas; thus, even though there may be a minimum of precipitation, frozen ground prevents drainage and there may appear to be much water everywhere.

7. Summer daylight in the north lasts for 24 hr but winter nights are equally long.

Sources of Water Supply

Ice and snow are the principal wintertime sources of supply in northern and central Alaska, except at some government installations and a few of the largest communities. It is not uncommon to find both ground and surface supply sources yielding water at 32°F, or only slightly above this temperature.

Icing problems at an intake structure are minimized by creating a deep pool of water over the intake and locating the latter several feet below the surface, regulating the water height to keep an ice cover over the intake pool, and maintaining low intake velocities to aid in preventing the structure from choking with frazil ice. Steam and electrical heating facilities are used at some places to provide the small temperature rise necessary to prevent icing.

Wells that pass through permafrost will freeze unless sufficient heat is provided in the casing to make up the heat losses from it. In some places, well freezing is prevented by controlling pumping time and rate, while, at other places, the well is warmed by periodically adding a quantity of hot water. Recirculation of heated antifreeze through a coil in the well and use of electric heaters are other ways to prevent freezing.

Conventional grouting and well slab construction to prevent drainage of waste water and other contaminated water into a well must be modified where the well is located in permafrost. In some installations these problems have been overcome by extending the well casing sufficiently above ground to permit construction of a deflecting metal apron welded directly to the casing in a heated well house. The apron does not conduct heat, as a concrete slab does, and directs water away from the well to a point where it will not seep down along the casing. The well house may be moved by frost heave and subsidence of the soil without damage to the casing or floor in the well house. A sliding metal sleeve around the casing permits movement of the well house floor.

Ice and snow as sources of supply are usually used by individuals and small groups. Snow and ice melters, consisting of heated coils in the bottom of a reservoir, are occasionally used to supply water for large groups. Snow and ice are most commonly placed in a large container in living quarters and allowed to melt slowly by the heat from the room.

Although most settlements are near the coasts of Alaska and readily accessible to sea water, civilians have not used distillation apparatus to secure water from the sea. Fuel or power, not readily available, are needed in considerable quantities for operation of distillation apparatus. In a few isolated localities, sewage effluents are reused because of the shortage of low-priced water. Although water supply methods employed by some people in the territory make the cost of water approximately $8.00 per hundred gallons, many individuals pay only $10.00–$15.00 per month for their supply.

Transmission and Distribution

Several methods have been employed in preventing water from freezing during transmission and dis-

tribution. Economical use and control of heat are the keys to practical and efficient operation and design of transmission and distribution works. If heat naturally present in the water is inadequate to satisfy heat losses from the system, the water must be warmed either in the system or at the source. At present these are the two principal methods used for warming potable water supplies:

1. Warming the water in the distribution system, by these techniques:

a. Use of steam tracer lines placed near the distribution pipe

b. Enclosure of the distribution line with a steamline or other heat source (electricity, hot air, and hot water) in a conduit (utilidor)

c. Location of distribution lines directly in the earth near sewers; placement of water lines in watercourses which do not freeze solidly.

2. Circulating water warmed at the source by:

a. Steam plant condensers

b. Heat exchangers

c. Water heaters

d. Hot-water boilers

e. Mixture with warm water from hot springs or other ground water sources.

Warming water in the distribution system is most commonly accomplished by use of a utilidor containing water, sewer, and other utilities. Improperly constructed utilidors in permafrost tend to thaw it, thus, destroying alignment of the structure and permitting ground water to seep into the utilidor. Sewer and water lines are then submerged under water within the utilidor. Occasionally, a breakdown of alignment or mechanical failure may cause sewage also to leak into the utilidor. In some instances, practically the entire sewage flow from an installation has been found to be discharging inside the utilidor and surrounding the enclosed water main. Mechanical arrangements for the drainage of utilidors are subject to failure, and unless continuous and adequate drainage is provided, undesirable conditions may occur at any time. The potential hazard created by flooding of utilidors is serious enough to cause a recommendation that all utilidors containing water mains be constructed to drain above grade or into an inhabited living or work area.

The practice of placing conventional water distribution lines in watercourses or in tidewaters which do not freeze presents hazards when such waters are polluted, particularly during periods of negative pressure in the water main. Wherever such practice is employed, it would appear desirable to require a quality of main construction comparable to that used in river and salt water crossings. The use of nonfreezing natural waters to protect pipelines should be avoided where other, more suitable, methods may be employed.

Warming water at the source at one Alaska installation involves the use of condensers or heat exchangers which could permit introduction of contamination into a potable water supply. The treatment plant and the water source are conveniently located near a steam-generating plant which supplies power and heat. After waste heat has raised the water's temperature, pumps circulate it through a specially designed distribution system. Because raw water and potable water are circulated though the heat exchangers, there is opportunity for mixture if there should be leakage between the two sides of the heat exchangers. The following general prac-

tices are desirable in an installation employing heat exchangers:

1. High- and low-quality water should not be circulated through the same side of the heat exchanger.

2. Heat exchangers should be so designed that the low-quality water is always under much less pressure than the high-quality water on the other side of the heat exchanger. The installation should be constructed of relatively noncorrodible material; in the event that water is seriously corrosive, treatment for corrosion control should precede the introduction of water into the heat exchanger. Distinguishing color schemes should be required and rigidly followed in designating all piping in a plant that utilizes waste heat sources.

3. Provision should be made for automatic stoppage of nonpotable water through the heat exchanger in the event that pressure in the low-quality side of the exchanger exceeds the pressure on the other side.

Piping in recirculating water systems is to be laid to grade and constructed for ready drainage. In permafrost it is difficult to provide drainage into gravel pockets or other uncontaminated areas. The drains for the water system should never be connected directly to a sewer.

In many areas of considerable ground frost, hydrants are commonly drained directly to a sanitary sewer, a practice capable of contaminating a conventional distribution system and even more dangerous in a recirculating system. All drainage must be accomplished without direct sewer connection and without discharge to gravel pockets in permafrost. For proper drainage, special access points to vents and pumps are provided on recirculating systems.

House service connections are perhaps the most frost-susceptible part of a system located in permafrost. In a utilidor distribution system, the service connection can be readily protected from freezing by use of heat from either the property to be served or from the utilidor. A dual-main distribution system with a low-pressure return main can be easily extended to provide circulation of warmed water through the service connection. In the single-main recirculating system, where it is more difficult to protect the service connection, such safeguard has been accomplished by adding warmed water to the waste, but has not proved desirable. A specially designed thermal tap (pitorifice) is used to circulate water from the single-main recirculating system through the service connection. The pitorifice, made in the utility's own shop, is a modification of the pitot tube. Water circulating in the street main induces circulation of warmed water in the house service pipe. Although such a procedure had been used for several years in single-pipe hot-water heating systems for homes, not until 1948 was it suggested for use in community water distribution systems; five years later the method was actually put to use in Alaska.

Circulation of water through a service connection increases the hazard of contaminating a water system from faulty house plumbing. In addition, the operating characteristics of a recirculating system make it easy to spread contamination to all parts of the distribution system.

These practices have been used to prevent freezing of fire hydrants:

1. Hydrants are drained, and in some instances antifreeze is placed in them.

2. The hydrants are pumped dry where proper natural drainage does not occur.

3. Specially designed insulated aluminum covers are usually placed over the fire hydrants in one community, although thick wooden boxes or cylindrical covers have also been used.

4. Hydrants connected to some of the utilidor distribution systems are enclosed in heated boxlike portions of the utilidor which extend to the surface of the ground.

5. Individual house services are tapped into the base of hydrants, wherever possible, to maintain flow of warm water.

6. Hydrants are located as close to the main as possible.

7. Kerosene lanterns are placed in hydrant boxes in one community as soon as the temperature drops to 20°F.

8. Steam tracers are placed along hydrants in railroad yards.

9. Electrical heating units are used occasionally, but in many places hydrants are fitted with sheathed copper cable thaw wire. Arc welders are readily attached to the wire for quick heating, and periodic thawing is carried out during extremely cold weather.

Water Treatment

Low water temperatures signify slow chemical reactions, large amounts of DO, increased tendency for sediments to remain in suspension and various other changes in water characteristics. Contact chambers following chlorination have been installed in some systems. Although one rapid sand filter plant, of about 30 mgd capacity, is effectively treating water without preheating it prior to the introduction of chemicals, other installations find it desirable to arrange for heating the raw water before treatment. Aeration equipment, especially, must be protected from freezing, and treatment processes must generally have weather protection. Because of serious condensation problems in water plants, it has been found best to provide adequate insulation and vapor barriers, as well as ventilation and air conditioning. Metal electric conduit and switch boxes connected directly through the building wall to the outside often become so coated with ice formed from condensation that they are completely unworkable. Weatherproofing and ventilation without regard for contaminants in the air have created some problems, causing trouble in at least one instance.

Structures on permanently frozen soil, which is unstable when thawed, have been fitted with cooling coils under footings. Refrigerant circulated through the coils keeps the permafrost intact, maintaining structural stability. Weir plates and other treatment plant equipment that may be made ineffective when moved out of level by a shift of the enclosing structure have been constructed so that compensating adjustment may be made easily.

Alaska water works operators and designers are using many ingenious methods to supply water to people and industry even though the water may be close to freezing and source and distribution facilities are located on permanently frozen ground. Because low temperature changes most of the warm-weather characteristics of water, many conventional methods for water collection, treatment, and distribution have been modified for use in the permafrost region. There is need for further research and study of low-temperature supply problems.

Mixing and Sedimentation Basins

——Revision of 'Water Quality and Treatment,' Chapter 8——

A revision of Chapter 8 of the second edition of Water Quality and Treatment (*American Water Works Assn., New York, 1950*), *prepared by AWWA Committee E5.B2—Revision, Chapter on Mixing, Flocculation, Settling. The members of the committee were: H. E. Lordley (Chairman), H. B. Gotaas, R. W. Haywood, L. J. Murphy, F. G. Nelson, C. W. Reh, T. B. Robinson, and R. A. Thuma.*

1. Coagulation and Sedimentation

The distinction between mixing basins and sedimentation basins is the same as the distinction between the coagulation process and sedimentation process. As described in Chapter 7, coagulation involves the addition of chemicals to the water, their uniform distribution through the water, and the building up of a readily settlable floc, usually by prolonged agitation of the water. Coagulation is accomplished by appropriate equipment in three steps or phases of mixing, floc formation, and conditioning. The functional difference in these transitional steps is one of decreasing agitation. The initial high-speed mix insures adequate, prompt dispersion of chemicals in the water being treated. The intermediate mix, at a lower speed, starts floc formation or coagulation, while the final mix is a gentle, slow movement that promotes further floc buildup and conditioning.

Sedimentation is the process by which coagulated or suspended matter separates from the water by subsidence and deposition. An effective means of water treatment, sedimentation does not depend upon coagulation, but is made more effective by it. Long before the benefits of coagulation were known to water works men, plain sedimentation was in general use.

The following definitions should be noted:

1. *Rapid or flash mixing* is the process by which a coagulant is rapidly and uniformly dispersed through the mass of the water. This process usually occurs in a small basin immediately preceding or at the head end of the "coagulation basin."

2. *Flocculation* is the stimulation by mechanical means of the coalescence of the suspended matter into compact, fast-settling flocs. This process usually occurs in the "mixing basin" or "coagulation basin."

3. *Sedimentation* is the separation by gravity of the flocculated solids from the water. This process occurs in the sedimentation basin, sometimes referred to as the "settling basin."

2. Introduction of the Mixing Basin

The value of adequate coagulation was apparently not known to the early designers of rapid sand filtration plants, although M. N. Baker (*1*) describes a plant, built by the Vicksburg, Miss., water works in 1887–88, which included coagulation and sedimentation basins with a lateral-flow filter. George W. Fuller, at Louisville, apparently conducted all his experiments on the treatment of Ohio River water without giving consideration to mixing basins, for there is no reference to their

use in his report (*2*). Milton F. Stein, in the first edition of his work on water treatment (*3*), presented a sketch of a mechanical filter plant which included only a settling basin and had no provision for coagulation basins. A review of water works literature, however, indicates that, after 1915, coagulation and sedimentation were used by most engineers in connection with rapid sand filtration.

Mixing basins are coming into wide use, as shown by Bean (*4*). He reports that in the installations in service, built or remodeled during the period 1922–32, 10 per cent had no mix, 8 per cent had spiral flow, and the other 82 per cent were about two-thirds baffled and one-third mechanically agitated. For installations built or remodeled during 1933–51, less than 2 per cent had no mix, 2 per cent had spiral flow, 6 per cent had baffles, 80 per cent used mechanical mixing, and 10 per cent employed other methods.

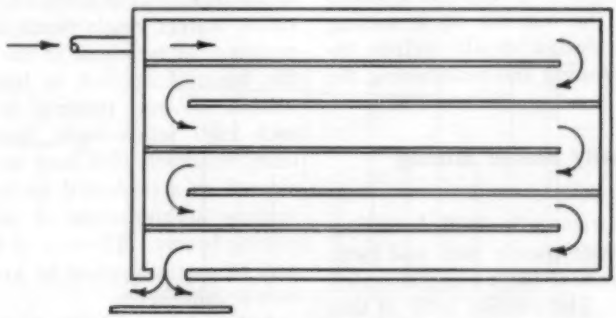

Fig. 8–1. Round-the-End Baffled Mixing Basin

The water travels back and forth around the ends of the baffles.

3. Conduit Mixing Basins

From the very beginning of the use of coagulation, it was realized that the chemicals should be uniformly distributed throughout the water to be treated, but it was thought that if sufficient time was available for the uniform distribution of the chemicals, or if other means for the dispersal of chemicals were available, no further provisions for coagulation were necessary. Sometimes the coagulant was added to the water before it passed through the low-lift pumps, which probably produced a very rapid initial mixing, but no facilities were provided for flocculation. As it was noted that time was important, the raw-water conduits were sometimes used as mixing basins. The greatest trouble encountered in doing so lies in the length of conduit required for good coagulation. The coagulant must be added at a point sufficiently distant from the settling basins to permit some building up of the floc. Flocculation does occur in conduits with a straight-line flow, but in order to obtain the necessary turbulence for mixing, the velocity of flow must be high and the coagulation period must be long. At the St. Louis Chain of Rocks Plant, the velocity in the conduit is 3.3 fps at a flow of 150 mgd and the length of the conduit is 9,528 ft.

Other difficulties may be experienced in the use of pipelines or various closed conduits as mixing basins. De-

posits from the chemicals may accumulate—especially when lime is added to the water—and may be difficult to remove. If chemicals are fed into lines under pressure, trouble may occur from air binding in the chemical lines. Usually, the provision of a long line merely to coagulate the water is not as economical as the conventional type of baffled basin or mechanical mixing basin. Where a line is necessary for transporting raw water and where it is convenient to have the chemicals applied at some distance from the settling basins, it may be reasonable to consider the use of the conduit as a mixing basin. The design should include facilities for cleaning and maintaining the conduit.

4. Horizontally Baffled Mixing Basins

In the horizontally baffled mixing basin, the water travels back and forth around the ends of baffles, as illustrated in Fig. 8–1. The outside walls of this type of basin are usually constructed of reinforced concrete, with grooves for the insertion of wooden baffles, which, in most recent designs, are made adjustable so that velocities of agitation can be changed, if necessary.

Flows through many plants may vary from one-fourth of rated capacity to more than rated capacity. Therefore, there are considerable fluctuations in the velocity through the mixing basins. The violence of agitation depends upon the velocity through the basin, in turn affecting the efficiency of coagulation. The lack of control of this agitation probably constitutes the most serious objection to baffled basins or, for that matter, to any coagulation device whose efficiency depends on the rate of flow.

Because the optimum violence of agitation is a function of the characteristics of the water, the kind of chemical used, the chemical dosage, the temperature of the water, and the period of coagulation, determination of the velocity of flow is one of the most difficult problems in the design of a mixing basin. For instance, a velocity of 2.0 fps, although generally considered excessive, might be the most desirable one for coagulating a highly turbid water in a specific basin. Again, a velocity of 1.0 fps, though acceptable in the treatment of a number of slightly turbid waters, might result in the accumulation of sediment at the bottom of the basin if applied to highly turbid waters. When treating waters with such high solids loads, however, primary sedimentation may well be considered as a preferred method of preventing accumulation of sediment in mixing basins. The cost of installation may be partially offset by lower coagulant requirements.

In the absence of specific data, Baylis (*5*) has suggested that a velocity of about 1.3 fps for operation at rated capacity is probably the most desirable speed for highly turbid waters. On the same basis, he suggests a velocity of 0.8 fps for waters of low turbidity and a maximum of 1.0 fps for slightly turbid waters. Where the turbidity fluctuates from low to high, velocities may be related to the mean turbidity.

It is quite evident that, for the first few minutes when the coagulant is being dispersed, the velocities may be much greater without interfering with the final flocculation of the water. Also, it should be noted that there will be very localized, short-period, high velocities as the water passes around the ends of the baffles, with the

eddies thus formed undoubtedly playing an important part in producing effective coagulation. The average loss of head appears to be between 2.0 and 3.5 times the velocity head for each 180-deg bend in the mixing basin.

5. Vertically Baffled Mixing Basins

Vertically baffled mixing basins are similar to the horizontally baffled type, except that in the latter, the water is directed vertically over and under a series of adjacent baffles, as shown in Fig. 8–2. Inasmuch as the direction of flow is the only significant difference between the two types of basins, their advantages and disadvantages are virtually the same. The alternate rise and fall of water obtained in the vertically baffled type is thought to be more effective in maintaining a homogeneous mixture of the suspended particles constituting the floc, thus preventing the undesirable deposition of sludge often encountered in horizontally baffled basins.

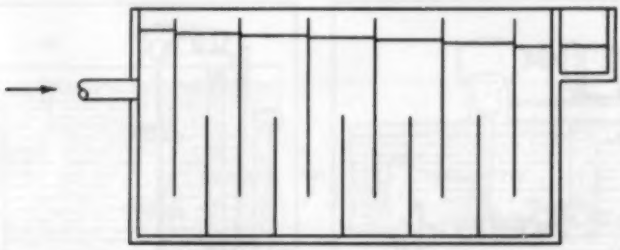

Fig. 8–2. Over-and-Under Baffled Mixing Chamber

The water is directed vertically over and under the adjacent baffles.

Little specific information is available on the best means of calculating the loss of head that will take place in horizontally and vertically baffled mixing basins. If the walls were perfectly smooth and straight, the friction loss could be computed with considerable accuracy by the use of hydraulic formulas, but this condition is not realized in practice. Furthermore, as the number of turns, supports, and bracing timbers varies considerably among different basins, even among those of the same general type, a coefficient determined for one might not be applicable to others. There is a much greater loss of head in a baffled mixing chamber than in those mechanically agitated, although with proper design the reduction may be kept at a minimum. An estimate of the head loss may be made by considering each lower pass as an orifice and each upper pass as a submerged weir.

6. Mechanical Mixing Basins

Mechanical mixing basins are provided with mechanical devices designed to agitate the water to be treated at the most desirable degrees of violence. Agitators were used in water softening for some time before their applicability to coagulation was appreciated. After the value of a prolonged period of agitation had been established, however, the use of mechanical agitators—capa-

ble of providing both the violent turbulence required in the mixing period and the gentler agitation in the flocculation period—soon came to be accepted practice.

7. Design of Mixing Basins

The required degree of turbulence is provided by a number of different mechanisms. Rapid or flash mixers are generally small in diameter, ranging from 3 ft to 10 ft, and revolve in a horizontal plane on a vertical axis, as illustrated in Fig. 8–3. The time required for flash mixing is short, ranging from 10 to 13 sec. The function of the flash mix is that of dispersing the coagulant through the water mass so that intimate and immediate contact is made. It is not desirable to cause formation of floc particles in flash mixers.

Equipment for floc formation should provide a gentler conditioning mix. One type of flocculation equipment, as illustrated in Fig. 8–4, consists of a series of paddles placed transversely across the tank width. These are arranged to impart a barrel roll effect to the water, a motion which causes the forming floc particles to pass through every zone in the water and brings the particles in contact with each other and suspended matter to cause a densening of the floc into small, globular particles which settle rapidly.

There are usually two or more rows of paddles, with appropriate baffles between them to effect an additional up-and-down travel to the floc particles. The paddles are driven by a motor, either constant or multiple speed, mounted on the tank wall, with a chain drive down to the shafts. It is advisable to install the drive elements in a dry well at the side or end of the tank and extend the ends of the shafts through the dry-well wall with bushings. Such installation permits constant inspection and lubrication of the chains and sprockets, avoiding the frequent replacement necessitated by corrosion and abrasion which could occur if the mechanism were submerged. Underwater bearings may be

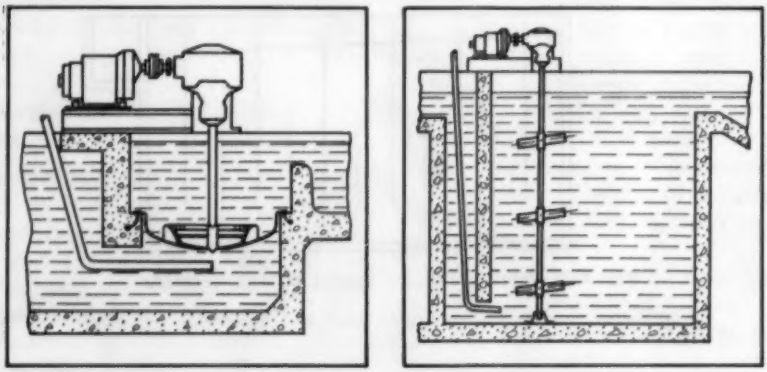

Fig. 8–3. Mechanical Mixing Tanks for Chemicals

The rapid or flash mixers revolve in a horizontal plane on a vertical axis.

provided with automatic lubricators, filled with grease, which permit operation for a year or more without refilling.

Another widely used type of flocculating equipment consists of a central shaft installed longitudinally in the center of the basin, parallel to the direction of flow; attached paddles rotate about the central shaft in a direction perpendicular to the flow. These models are usually designed with the paddle area decreasing in the direction of the flow to provide for diminishing agitation as the water progresses through the basin, while baffling is required at intervals to prevent the water from "coring" through the center of the basin along the shaft in the area of minimum turbulence. These units are usually equipped with variable speed drives. An advantage of the longitudinal shaft is that it can be driven through a stuffing box at one end of the basin, obviating a dry well for the drive chain.

Another mixer for floc conditioning is shown in Fig. 8–5. This type, which has variable speed drive and is readily adaptable to existing basins, is described in a 1944 JOURNAL AWWA article (*6*). The paper also has information on the computation of power requirements for mechanical mixing units.

Mixing basin designs and material of construction should be determined after an engineering investigation of the particular plant requirements. Mixing basins have been constructed of both steel and concrete and in various shapes, such as square, oblong, or circular. Practice has shown that, normally, a flocculation period of from 30 to 45 min—depending upon the character of the water—is required for good results.

The principal advantage of the mechanical mixing basin over other types is that mechanical mixing permits the maintenance of certain states of motion irrespective of rates of pumpage or filtration, as well as making readily possible the adjustment of flocculation velocity to suit changing conditions.

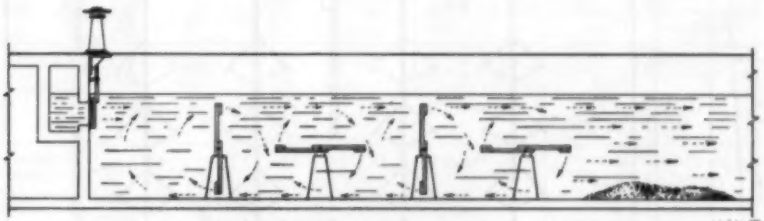

Fig. 8–4. Flocculating Equipment

A series of paddles placed transversely across the tank width are arranged to impart a barrel roll motion to the water.

8. Spiral-Inward-Flow Tanks

Spiral-inward-flow tanks are circular basins in which agitation is provided by tangentially introducing the water into the periphery of the basin. In some installations, the water is withdrawn at the center, in others, at the periphery, with the influent and effluent ports at different levels of the tank.

Aldrich (7) describes a plant using a spiral-inward-flow tank (see Fig. 8–6a and 8–6b) in which the mixing basin has a diameter of 24 ft and a depth of 15 ft. The detention time at a plant rate of 2 gpm per square foot of filter area is approximately 30 min. Chemicals are introduced into the raw-water pipeline and a quick mix is secured in the entrance line. The mixing is continued more slowly by the tangential introduction of the treated water at the top of the mixing chamber. The flocculated water leaves the mixing basin through baffled, horizontal slots near the bottom.

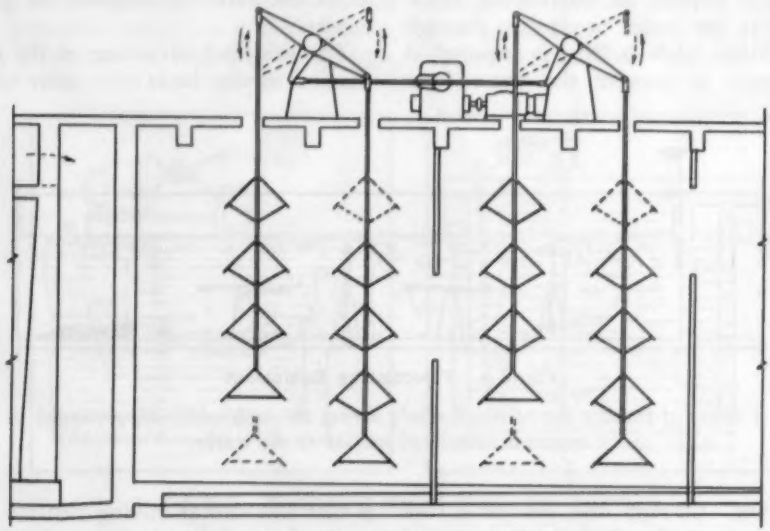

Fig. 8–5. Walking-Beam Installation on Top of Covered Basins

This mixer for floc conditioning has a variable-speed drive and is readily adaptable to existing basins.

9. Other Types of Mixing

Occasionally, unusual types of mixing basins or agitation devices are used in an effort to improve plant results. Prominent among these innovations are the hydraulic-jump method of agitation and the application of various aeration devices to aid coagulation.

The hydraulic jump is essentially a method of providing a rapid mix without the use of mechanical units. Coagulant is introduced into the water before it enters an open, sloping, and widening flume. Passing down the flume, the water acquires a high velocity, 10–12 fps. On reaching the bottom, the water enters a slowly moving pool. Here, some of the kinetic energy acquired in flowing down the flume is dissipated, resulting in considerable turbulence, which, in turn, insures a rapid initial mix. The head loss is at least 1 ft.

Aerating devices have been used for mixing and flocculation. Where such agitation is applied properly, it will produce very satisfactory results. It is

doubtful, however, whether it has any advantage over the conventional mechanical agitators.

10. Development of Sedimentation Practice

As a means of improving the quality of water for domestic use, sedimentation has been employed for many centuries (*1*). In ancient Egypt, the turbid floodwaters of the Nile were diverted to stilling basins and allowed to settle before distribution for domestic use. In the ruins of Carthage, the remains of large rain water storage and settling reservoirs, erected for public supply, have been found. In Rome, settling reservoirs for improvement of water quality were built before the Christian era.

In the United States, the first settling reservoir on record was a part of water works completed in 1829 for Lynchburg, Va. In 1874, Kansas City, Mo., in the treatment of a turbid river water constructed two long parallel compartments with water flowing lengthwise, down one unit and back through the other. In 1889, Omaha, Neb., started using aluminum sulfate as a coagulant ahead of the settling basins, and 34 years later, in 1923, filters were provided. Although New York City, the Boston Metropolitan Water Dist., Los Angeles, and other large cities have depended upon sedimentation in large reservoirs as the

TABLE 8–1

*Laws of Sedimentation**

Law	Equation	Exponent of Velocity (n)	Range of R to Which Law Applies	Relation Between C_D and R	Range of Particle Diameter to Which Law Applies When $\rho_s = 2.65$
General case	$v^n = \frac{4g}{3k}\left(\frac{\rho_s-\rho}{\rho}\right)\mu^{n-2}d^{2n-n}$	n	10^{-4} to 2.5×10^5	variable	maximum limit not specified
Stokes'	$v = \frac{1}{18}g\left(\frac{\rho_s-\rho}{\mu}\right)d^2$	1	10^{-4} to 0.55‡; 10^{-4} to 1.0‡	$C_D = \frac{24}{R}$	up to 0.0085 cm;‡ up to 0.01 cm‡
Allen's	$v = 0.22\left[\left(\frac{\rho_s-\rho}{\rho}\right)g\right]^{\frac{1}{2}}\left[\frac{d}{(\mu/\rho)^{\frac{1}{2}}}\right]$	1.5†	10 to 10^3	$C_D = \frac{12.65}{0.5R}$	>0.01 cm to <0.1 cm
Allen's modified (experimental)	$v = 0.25\left[\left(\frac{\rho_s-\rho}{\rho}\right)g\right]^{\frac{1}{2}}\left[\frac{d-0.4d^2}{(\mu/\rho)^{\frac{1}{2}}}\right]$	1.5† 1 to 2*	10 to 10^3	$C_D = \frac{12.65}{0.5R}$	>0.01 cm to <0.1 cm
Allen's modified	$v = 0.20\left[\left(\frac{\rho_s-\rho}{\rho}\right)g\right]^{0.72}\left[\frac{d^{1.18}}{(\mu/\rho)^{0.46}}\right]$	1.375†	1 to 10^3	$C_D = \frac{30}{0.625R}$	>0.01 cm to <0.1 cm
Newton's	$v = 10.36\sqrt{d\left(\frac{\rho_s-\rho}{\rho}\right)}$	2	10^3 to 25×10^5	$C_D = k = 0.4$	>0.1 cm

* The equations give velocities in cm/sec when: d is diameter (cm); g (cm/sec/sec) is acceleration due to gravity; ρ is density (g/cc) of liquid (for water, $\rho = 1.0$); ρ_s is density (g/cc) of particle; μ is viscosity (poises) of liquid ($\mu = 0.01309$ at 10°C); R is Reynolds number; C_D is overall drag coefficient; in applying the equations, use is generally made of Hazen's experimental evaluation of the relation between μ at 10°C and at any other temperature (T) expressed in °F. Hazen demonstrated that for water μ at any °F equals μ at 10°C multiplied by $\frac{60}{T(°F)+10}$ or $\mu_T = 0.01309\,\frac{60}{T+10}$; a similar equation developed by Poiseville for μ at any °C based on μ at 0°C states that:

$$\mu_c = \frac{0.0178}{1 + 0.03377\,Tc + 0.00022\,Tc^2}$$

† 1 to 2, approximately.
‡ Approximately.

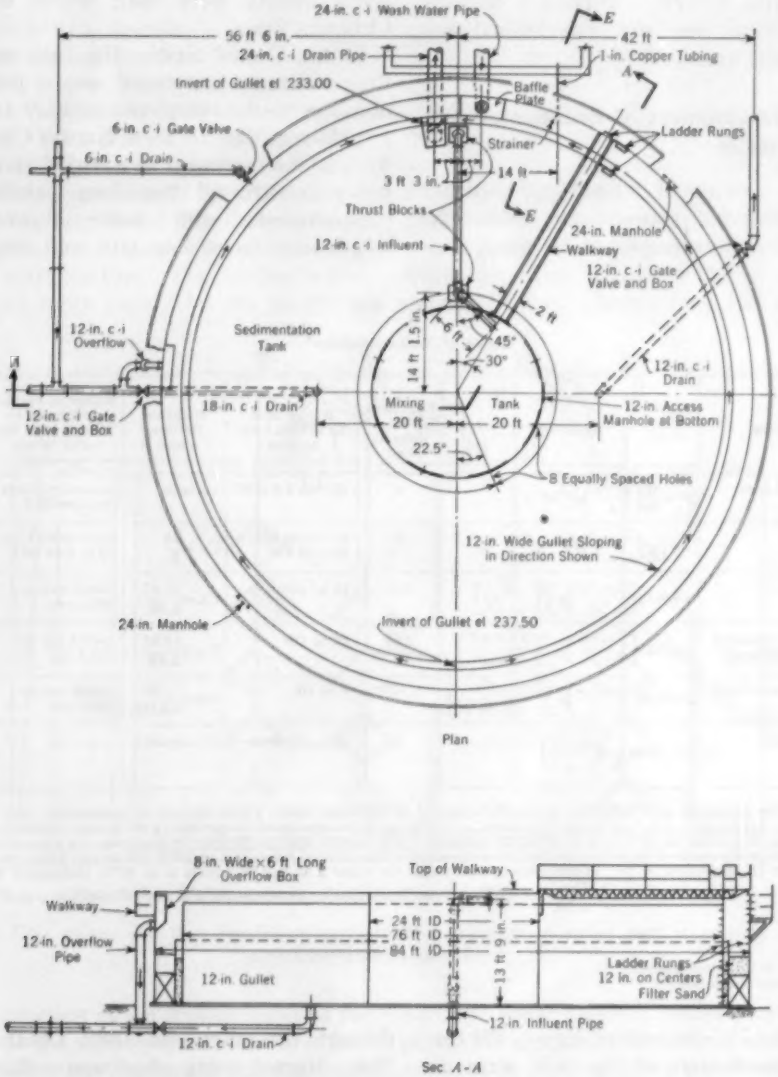

Fig. 8–6a. Diagrammatic Plan of Spiral-Inward-Flow Tank

The unit is a round steel tank constructed in the open. In the center is a circular mixing and flocculating compartment surrounded annularly by the settling compartment; the filter comprises the outside annular space with a drain gullet separating it from the settling basin. Section E–E is shown in Fig. 8–6b. These illustrations are taken from "A New Water Supply for the Alexandria Water Company" by E. H. Aldrich, Journal AWWA, Vol. 43, p. 332 (May 1951).

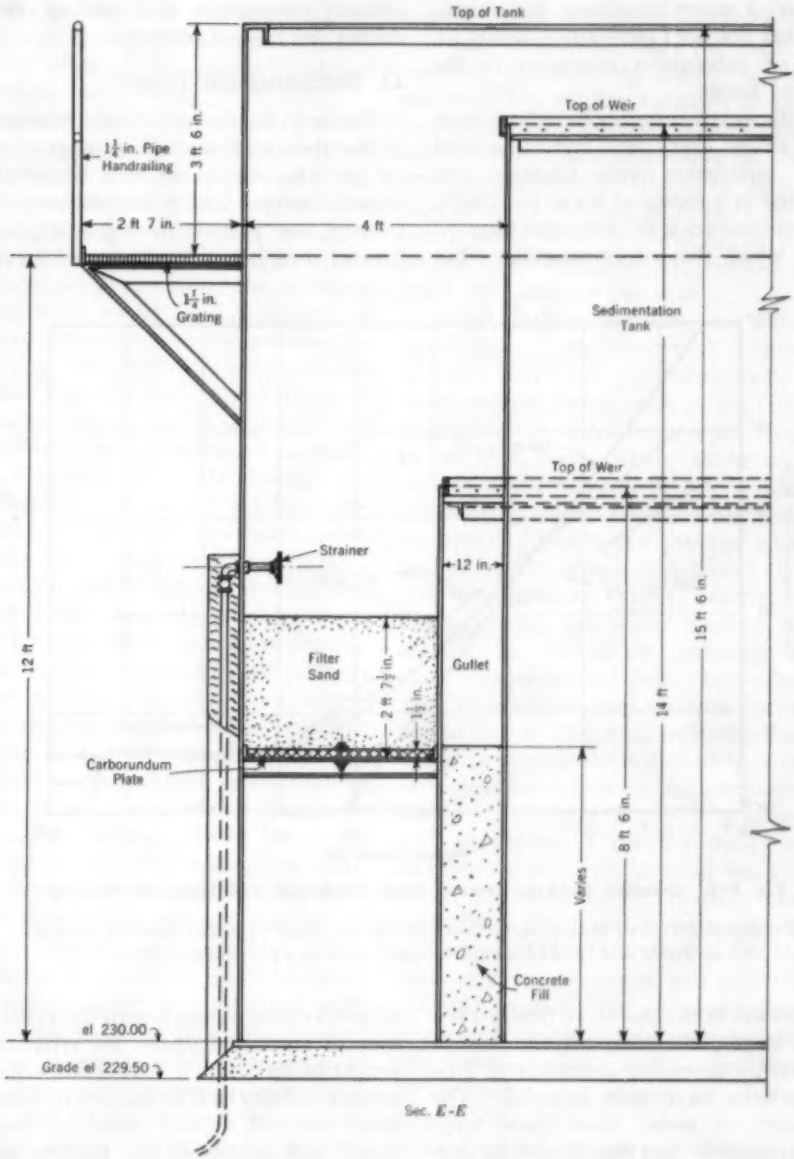

Fig. 8–6b. Cross Section of Filter Unit

This view of the outer portion of the treatment unit corresponds to Sec. E-E of the plan in Fig. 8–6a, on opposite page.

means of water treatment, sedimentation has not been generally relied upon without subsequent treatment in the United States.

Sedimentation basins have been used with almost every slow and rapid sand filter installation since filtration was adopted as a means of water treatment. In combination with slow sand filters—with which the use of coagulants has not always been considered necessary—very large plain sedimentation basins, frequently providing detention of 2 or more days, have been included. The turbidity of water from these large basins must be less than 5 ppm for satisfactory filtration. With rapid sand units, smaller basins are usually provided to handle coagulated waters. Current practices are directed to more efficient coagulation and settling, reducing the time of settling.

11. Sedimentation Theory

Basically, the theory of sedimentation is the theory of the effect of gravity on particles suspended in a liquid of lesser density. Under the influence of gravity, any particle having a density greater than 1.0 will settle in water at an accelerating velocity until the resistance of the liquid equals the effective weight of the particle. Thereafter the settling velocity will be essentially constant and will depend upon the size, shape, and density of the particle, as well as the density and viscosity of the water. For most theoretical and practical computations of settling velocities in sedimentation basins, the shape

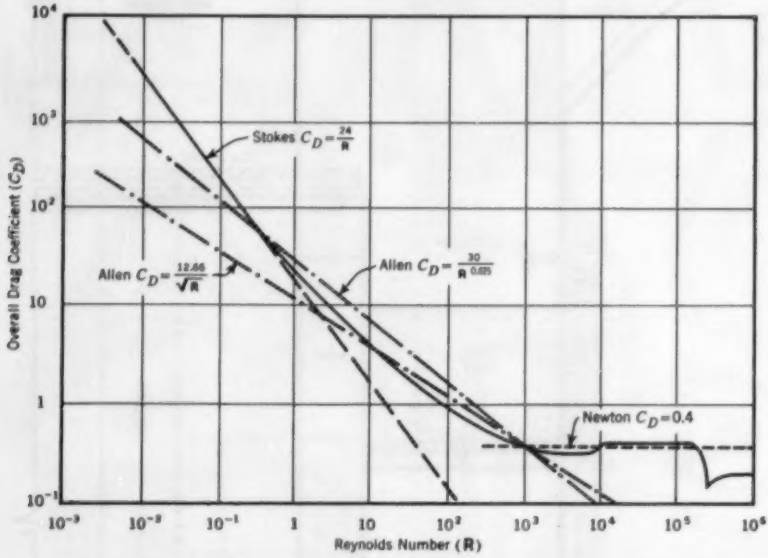

Fig. 8–7. Relation Between Overall Drag Coefficient and Reynolds Number

From these curves it is evident that the various laws of sedimentation shown in Table 8–1, p. 712, conform quite well to experimental data.

of the particles is assumed to be spherical. Settling velocities of particles of other shapes can be analyzed in relation to spheres.

From Fig. 8–7 it is evident that the various laws of sedimentation shown in Table 8–1 conform quite well to experimental data for discrete spheres settling through still water which is confined in a basin of sufficient cross-sectional area to render the influence of the walls negligible. A number of factors, however, greatly modify the situation in practical sedimentation basins. Specific gravity and shape of particles, coagulation or agglomeration of particles, concentration of particles, and movement of water through the settling tank are among the most important. Camp (*8*) notes that a turbid surface water may contain suspended matter ranging in specific gravity from about 2.65 for sand down to about 1.03 for flocculated particles of organic matter and mud containing 95 per cent water, while the floc particles resulting from coagulation may have a specific gravity of 1.18 for aluminum or 1.34 for iron oxides. These values may be increased by clay or silt, or drastically reduced by organic matter or by entrained or adsorbed water. In addition, irregularly shaped particles settle more slowly than spherical ones of the same volume and material. Sand grains and heavy floc particles settle out quite rapidly in a practical sedimentation basin. As they represent only a relatively small proportion of the particulate matter present, however, most of the particles settle at velocities within the range of Stokes' law.

Variety in shape, size, and specific gravity of particles results in a wide range of settling velocities, which, by causing some subsiding particles to overtake others, increases the natural tendency of suspended matter to flocculate. Thus, settling velocities change as the subsiding material varies in size and density. Camp (*8*) points out that these speeds may be reduced by 10 per cent or more because of velocity field interference between particles, if the concentration of suspended particles is more than about 1 per cent.

Actual settling velocities may differ significantly from theoretical because of water movement in continuous-flow sedimentation basins such as are commonly used in water treatment. Even in an ideal basin, where all velocity vectors would be equal and horizontal, the moving water would have some transporting power and produce some bottom scour. In actual basins, the retarding effect on settling exerted by transportation and scour may be increased by turbulence, although in many instances turbulence and other velocity gradients may increase flocculation, thereby hastening sedimentation.

For predicting the degree of removal of suspended matter by sedimentation basins in treatment plants, it is necessary to develop a rational theory of clarification based on an ideal basin in which sedimentation of discrete particles takes place just as in a tank of still water of the same depth. On the basis of experimentation and theoretical considerations, the effect of turbulence and particle agglomeration on the sedimentation process can then be estimated and a basis for design established.

Very significant work in developing a rational theory for an ideal basin and modifying it for practical sedimentation basin design has been carried out by Camp (*8–11*). His rational

analysis of an ideal basin may be developed from considerations illustrated in Fig. 8-8.

A unit of water entering the ideal sedimentation basin at the left is assumed to spread out uniformly over a vertical plane A–A in such a manner that the concentration of suspended particles of all sizes and densities is constant throughout an incremental volume of the tank, which has a length of ΔL. The area in which this process takes place is called the inlet zone. The incremental volume of water moves from inlet to outlet, through the settling zone, at a uniform velocity (v) and arrives at the position A'–A' without change in shape. In the outlet zone, increments of water reassemble from all parts of the plane A'–A' to reconstitute the original unit of water, carrying along all the particles which are not removed in the settling zone.

Assuming that all particles settle discretely and that those which strike the bottom are removed, the absolute velocity path (V) represents the maximum elevation where particles of the smallest diameter (d_0) which will experience 100 per cent removal may be found. A particle of diameter d_0 which enters the basin at the water surface (at height h_0 above the bottom) will travel along the path V and be removed just as the water moving at velocity v enters the outlet zone. All other particles of the same diameter and density will follow parallel paths and be removed nearer the inlet end of the basin. The settling velocity (v_0) of the particle will, of course, be governed by its diameter and density, following the appropriate law of sedimentation.

Under practical conditions, particles which strike the bottom of a tank may not be removed, but, instead, may roll along the bottom. The horizontal velocity at which this occurs is known as the critical velocity. Available information indicates that in a properly designed basin the ratio of the mean horizontal velocity in the tank to the settling velocity of the smallest particle which will be removed should not exceed 20:1 to 40:1.

Particles of diameter d_1, less than d_0, but of the same density, will follow an absolute path parallel to V'. Consequently, they will be carried over the outlet if they originate above h_1 in the plane A'–A, or be removed if they enter the tank at a lower elevation.

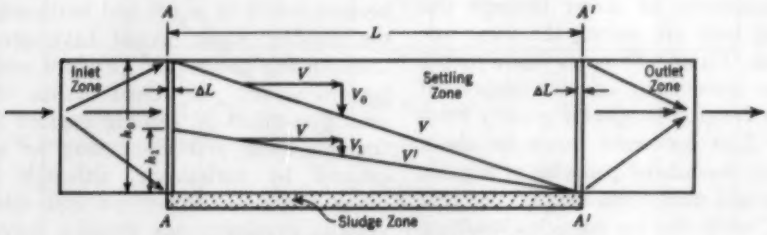

Fig. 8-8. Ideal Sedimentation Basin

For an explanation of symbols employed, see text, pp. 780 and 781.

Because

$$\frac{v_0}{v_1} = \frac{h_0}{h_1}$$

it may be concluded that the percentage removal of particles smaller than d_0, but of the same specific gravity, will equal $\frac{v_1}{v_0} \times 100$, with v_0 and v_1 being determined by the appropriate law of sedimentation.

The time required for a particle of diameter d_0 to settle through a depth h_0 at velocity v_0 is:

$$t = \frac{h_0}{v_0}, \text{ or } v_0 = \frac{h_0}{t}$$

As, also:

$$t = \frac{\text{volume of basin}}{\text{inflow rate } (Q)}$$

and volume equals surface area (A) times h_0, then:

$$t = \frac{Ah_0}{Q} \text{ and } v_0 = \frac{h_0}{\frac{Ah_0}{Q}}$$

Therefore:

$$v_0 = \frac{Q}{A}$$

or by Stokes' Law,

$$d_0 = k(v_0{}^1) = k\left(\frac{Q}{A}\right)^1$$

Hence, it is apparent that the smallest diameter of particle which will be completely removed is theoretically a function of the surface loading or overflow rate rather than of the depth of the tank. This is true for nonagglomerating particles such as silt when no velocity field interference occurs, but may not be absolutely correct for floc particles which may agglomerate while settling. In any event, surface loading is the most important criterion of sedimentation efficiency when the horizontal velocities in the basin are approximately uniform. Some typical settling velocities and surface loading rates are:

Alum floc—settling velocity, 2–3 feet per hour (fph); loading rate, 360–540 gpd per square foot.

Lime softening floc—settling velocity, 3–6 fph; loading rate, 540–1,080 gpd per square foot.

Vertical upflow clarifier with lime floc sludge blanket—upflow velocity, 6–12 fph; loading rate, 1,080–2,160 gpd per square foot.

Camp (*8*) has further refined the theory of clarification from both rational and empirical considerations to permit a prediction of the concentration of particles at any depth in a sedimentation basin and make possible a design which closely approximates the ideal basin.

12. Experimental Work

Mixing and settling exhibit certain characteristics which are general to all waters. Because the latter are dissimilar, however, continuous experimentation is necessary for new plant design, development of coagulation theory, and improvement of plant operation. Experimental data may be obtained from models, pilot plants, laboratories, and operating installations.

Models for settling basin design require both geometric and dynamic similarity, a condition which can be achieved in hydraulic studies. A model built by Morrill (*12*) was used with considerable success in predicting the performance of the sedimentation basins for the Springwells Plant at Detroit. Although models are useful for hydraulic studies, Camp (*8*) points out that geometric models are not satisfactory for coagulation studies because

there is no practical way of scaling down the particles to be settled.

Experimental plants have been operated for the purpose of developing general theory and determining design criteria. Bloodgood (*13*) operated an experimental tank to ascertain the effects of varying tank dimensions on settling efficiency. The maximum measurements of the tank used for the determinations were: 14.5-ft length, 6.0-ft width, and 3.0-ft depth. Baylis operated an experimental plant over a continuous period of 14 years to determine the design criteria for the Chicago South Dist. Filtration Plant. The experimental apparatus was designed with all the components of a rapid sand filtration plant with a nominal capacity of 0.5 mgd. The installation was arranged with great flexibility so that mixing and settling time could be varied, several types of mixing could be employed, and simultaneous experiments could be performed.

Laboratory experiments—usually specific for a particular water—are used both for plant design and for the improvement of plant performance. Experiments for plant design include studies on comparative efficiencies of available coagulants, dosages, rates of agitation, and sedimentation rates. In discussing the improvement of plant performance, Lee Streicher, Chief Chemist, Metropolitan Water Dist. of Southern California, noted that water coagulated with activated silica and lime, while producing a water low in turbidity, did not improve filter runs. He believes that turbidity may not be a suitable index for measuring sedimentation basin performance and that laboratory studies are necessary to develop an index of "filterability" of the water. Plant scale experiments should be used to test the results of laboratory studies.

If the performance of plants in normal operation can be objectively analyzed, the data so obtained may be of great value in the design of a new plant. Care must be exercised to insure that the characteristics of water treated in the existing plant are similar to those expected in the new one.

13. Purpose of Sedimentation Basins

Sedimentation basins are designed to remove natural and flocculated turbidity prior to filtration. Pretreatment by efficient mixing and flocculation units, prior to sedimentation, normally delivers a water of low turbidity (1–5 ppm), which should be suitable for rapid sand filtration.

Where sedimentation without subsequent filtration is practiced, the basins have ordinarily been constructed along the lines of large storage reservoirs, providing from one to several days' settling before the water is pumped to the distribution system.

14. Factors Affecting Design

Sedimentation basin designs have been based principally on the experience and judgment of the engineer and on studies of the design of existing plants treating the same or similar waters. There are, however, these important points other than structure to be considered in designing the basins:

a. Plant capacity
b. Type of treatment and characteristics of water
c. Number of basins
d. Size and shape of basins
e. Inlet arrangement
f. Intermediate arrangement
g. Outlet arrangement

h. Detention period
i. Velocity of flow through basins
j. Sludge storage and cleaning
k. Sludge removal devices
l. Cover

Each of these points is discussed in succeeding paragraphs.

15. Plant Capacity

The most important aspect of plant capacity is the maximum rate of operation. Sedimentation basins must be designed so that no deterioration of settled-water quality will occur during the peak periods. Any such deterioration may impose greater demands for filter wash water, leading to further lowering of quality.

16. Type of Treatment and Characteristics of Water

The source of the water supply—lakes, rivers, or wells—affects the characteristics of the raw water. The nature of the suspended matter, chemical treatment required to coagulate the water, variations in the amount of suspended matter, and effects of temperature upon coagulation and sedimentation efficiency are among the factors which influence the design of sedimentation basins.

17. Number of Basins

Probably the most important considerations in the selection of the number of basins are: [1] the effect upon the production of water if one basin is removed from service, and [2] the largest size which can be expected to produce satisfactory results. Plant layout and site conditions also may influence the number of basins.

If there is only a single basin, its removal from service may make the consumption of raw water necessary. For any supply which requires coagulation and filtration for the production of safe water, a minimum of two basins should be provided. The greater the number available, the less will be the effect upon velocity and detention period in the remaining basins should one be out of service, for cleaning, repairs, or any other reason.

18. Size and Shape of Basins

The most common forms of sedimentation basins are circular, square, or rectangular. The selection of the particular form or shape for a given plant depends upon area available, conformity with adjacent structures, and the theories and experience of the designing engineer. The majority of sedimentation basins now in use are rectangular in shape and of reinforced concrete construction. Circular basins of either concrete or steel have been used widely for both coagulation and softening.

Special considerations may prompt some unusual designs. At Burnt Mills, Md., for instance, the space between two circular steel tank sedimentation basins is used for a mixing basin. At the Dalecarlia Filter Plant, Washington, D.C., a two-story coagulation-sedimentation basin operates with water entering at the bottom, flowing across, and then going upward to return through the top section. The head end of the lower basin is equipped with flocculating equipment. At Lynchburg, Va., coagulation-sedimentation basins are arranged in a 70-ft vertical steel tank, raw water entering at the top and settled water leaving the bottom for filtration.

The size of basins is a function of most of the items tabulated in Sec. 14. Small circular basins only a few feet in diameter, and rectangular basins as

much as 1,660 ft in length, 400 ft wide and 23 ft deep are in operation.

Most sedimentation basins are provided with sloping bottoms to facilitate the removal of deposited sludge. Although the optimum depth of a basin is a controversial matter, a review of the design of the larger rapid sand filtration plants indicates an average depth of about 16 ft. For most conditions, this is believed reasonable.

19. Inlet Arrangement

The purpose of inlets is to distribute the coagulated water uniformly among the basins and uniformly over the cross section of each sedimentation basin. Properly designed inlets and outlets are necessary to avoid short-circuiting through a basin. The most efficient and satisfactory inlet is one which permits water from the coagulation basin to enter directly into the sedimentation basin without the use of pipelines or flumes. As treatment plants operate over a relatively wide range of flow—from low winter to maximum summer demands—velocities occurring in the inlet pipeline or flume may be either so low that settling takes place or so high that the floc is broken before it reaches the basin. The permissible velocity range for any water and floc can be determined by tests, but velocities between 0.5 and 2 fps are usually satisfactory.

Where inlet pipelines or flumes are required, several methods have been used to give uniform distribution of the floc, as shown in Fig. 8–9. To obtain uniform flow through each of the inlet pipes or orifices, the head loss at each opening should be large compared to the maximum difference of energy head available at the inlets. Velocities, however, must be maintained sufficiently low to prevent breaking up of floc.

Circular basins fed at one side for discharge at the opposite side are not efficient, because the provision of influent and effluent channels around the arc of the periphery results in dead areas in the tank and short-circuiting of the flow across it. Circular tanks fed from a central inverted siphon with an effluent weir passing around the entire periphery are very efficient. In these, the velocity of flow drops constantly during the passage of the water radially from the center inlet point to the discharge weir, and the settling solids drop rapidly in a conelike pile close to the center of the tank. The long effluent weir, equal to the periphery of the tank, permits a very thin film

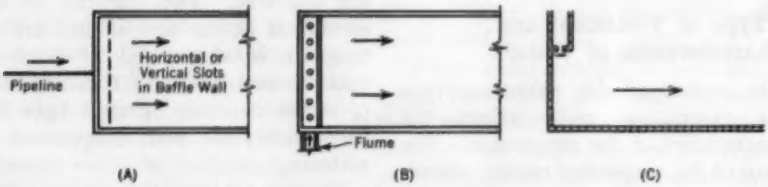

Fig. 8–9. Inlet Arrangements

A—*Plan view of basin with pipeline inlet;* B—*plan view of basin with flume inlet;* C—*section view of* B.

of water to pass. Square tanks may be fed from the center in a similar manner or from one side across to the other, with equal efficiency.

20. Intermediate Arrangement

The use of baffles in sedimentation basins to reduce short-circuiting and improve settling efficiency is common to many plants. In plants using one basin for mixing, coagulation, and sedimentation, a baffle is often installed across the basin between the coagulation and sedimentation sections, extending approximately 50 per cent of the vertical distance from the top of the water to the floor. Although such an arrangement does tend to correct short-circuiting, it may form dead spaces, produce eddy currents, and cause disturbance of the deposited solids. Another method of reducing short-circuiting is the use of longitudinal round-the-end baffles, which also serve the purpose of bringing water in at one end of the basin and returning it to that end before it goes on to the next step in the treatment process. Intermediate baffling has been less popular in recent years because of increased costs of construction and the use of mechanical mixing and flocculation to produce a floc having superior settling characteristics.

21. Outlet Arrangement

Water leaving the sedimentation basin should be collected uniformly across the width of the basin to prevent high velocities of approach and consequent lifting of the settled sludge over the weir. The outlet arrangement for circular basins with center inlet, described in Sec. 19, provides an efficient outlet.

In rectangular basins, weirs may be constructed across the basin, or slots or effluent ports provided. Freely discharging weirs have a tendency to break fragile floc. Combinations of effluent orifices ahead of the submerged weir provide efficient outlet arrangements and reduce short-circuiting. In some designs, collecting weirs and flumes which begin at the middle of the basin to give great weir length have been constructed. Insufficient length results in excessive overflow rates and consequent high velocity of approach to the weir. Frequently, in basins of insufficient weir length, settled solids are pulled from the floor of the basin by high velocity of approach, nullifying

TABLE 8–2

*Velocities at Which Particles of Sand and Silt Subside in Still Water**

Diameter of Particle *mm*	Order of Magnitude†	Hydraulic Subsiding Value *mm/sec*	Time Required to Settle 1 ft
10.0	gravel	1,000	0.3 sec
1.0		100	3.0 sec
0.8		83	
0.6		63	
0.5		53	
0.4	coarse sand	42	
0.3		32	
0.2		21	
0.15		15	38.0 sec
0.10		8	
0.08		6	
0.06		3.8	
0.05		2.9	
0.04	fine sand	2.1	
0.03		1.3	
0.02		0.62	
0.015		0.35	33.0 min
0.010		0.154	
0.008		0.098	
0.006		0.055	
0.005		0.0385	
0.004	silt	0.0247	
0.003		0.0138	
0.002		0.0062	
0.0015		0.0035	35.0 hr
0.001	bacteria	0.00154	230.0 days
0.0001	clay particles	0.0000154	63.0 years
0.00001	colloidal particles	0.000000154	

* Temperature, 10°C. (50°F); specific gravity of sand and silt particles, 2.65; values for 10-mm to 0.1-mm particles from Hazen's experiments; values for 0.02-mm to 0.00001-mm particles from Wiley's formula; intermediate values interpolated from connecting curve.

† Order of magnitude given is merely a comparative expression; the particles throughout were computed on the basis of sand and silt of 2.65 sp gr.

the good settling which had been achieved.

22. Detention Time

The time theoretically required for a unit volume of water to flow through a mixing or sedimentation basin is called the "detention time." It is equal to the time required to fill the basin at a given rate of flow, and can be computed by dividing the volume of the basin by the rate of flow through it.

Detention time must be distinguished from the "flowing-through time," the

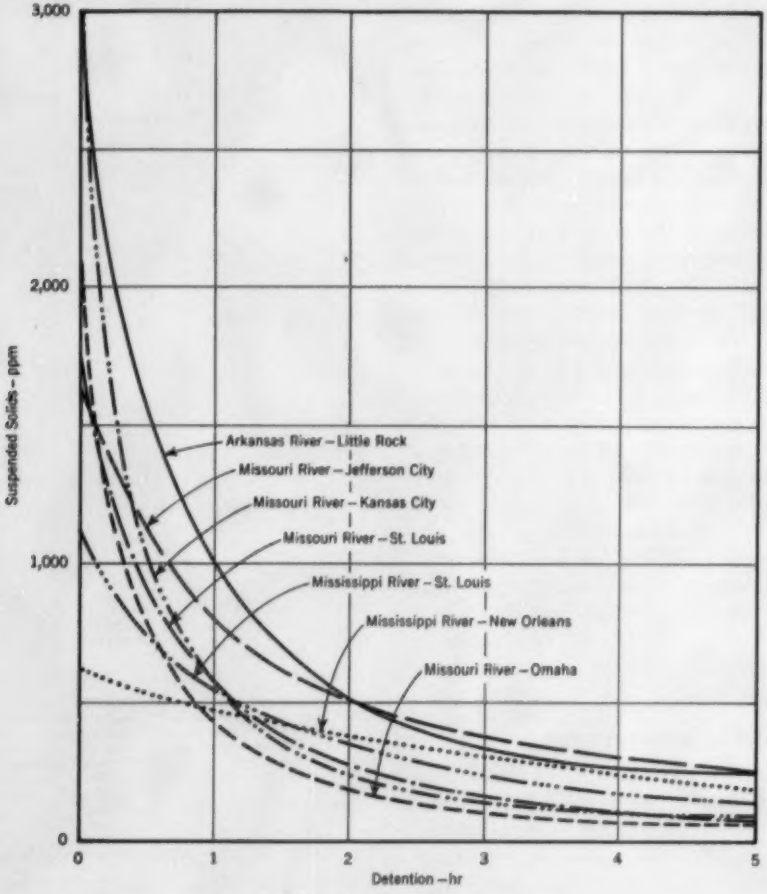

Fig. 8–10. Coarse-Particle Removal

Major removals of coarse, rapid-settling sand and silt may be effected in 1–3 hr, as shown at seven locations in the United States. The illustration was originally published in "Sedimentation Studies of Turbid American River Waters" by A. W. Bull and G. M. Darby, Journal AWWA, Vol. 19, p. 239 (Mar. 1928).

minimum time required for a particle of water to pass through the basin. The detention period may vary from two to twenty times the flowing-through period, depending upon the shape and dimensions of the basin, the design of the inlet and outlet structures and baffles, and other factors which affect the degree of short-circuiting that occurs in the basin.

Theoretically, the settlement of suspended particles in a sedimentation tank is influenced primarily by particle sizes and their specific gravities, as indicated in Table 8–2. Actually, other factors may have an equal or greater influence. They are: [1] coagulation or coalescence of the settling particles; [2] depth and shape of the basin; [3] viscosity (temperature) of the water; [4] presence of convection or wind currents; [5] method of operation of the basin; [6] electrical phenomena; and [7] biological activity. Hazen, Slade, Camp, Carpenter, Speiden and others have developed theoretical mathematical formulas for settling tank design. The unknown variables, however, are so many that most engineers find it necessary to modify the results obtained, using judgment based on successful experience, when determining the desirable detention time or other aspects of settling tank design. Obviously the detention time must always be long enough to permit the particles of desired size to fall to the bottom before reaching the outlet.

The desirable detention time is affected by the purpose of the basin. In a mechanically cleaned presedimentation basin, the detention time may be sufficient for the removal of only the coarse, rapid-settling sand and silt. Major removals of these solids may be effected in 1–3 hr, as shown in Fig. 8–10.

In a plain sedimentation basin, depended upon for removal of fine suspended solids, the detention time must be long—in fact, the longer the better—as small particles settle very slowly. Ordinarily, basins large enough to give a detention period of several days or weeks are not economical, but special conditions may dictate their use in place of or as a supplement to mixing and coagulation basins.

In a properly designed settling basin which handles well coagulated water, a detention time of from 2 to 4 hr is usually sufficient to prepare the water for filtration. When economy is not a governing factor or where a high degree of suspended-solids removal is desired, the settling basins may be somewhat larger than required for minimum detention.

Suspended solids removal in a settling basin is largely a function of detention time, with by far the greater amount removed in the first few hours. Detention time must, therefore, be long enough to give the desired removal, but is usually limited to a few hours by economic considerations and by rapidly diminishing returns in terms of suspended matter removed.

23. Velocity of Flow Through Sedimentation Basins

A survey of 60 large rapid sand filtration plants shows that theoretical velocities vary from a minimum of 0.5 to a maximum of 5.7 fpm, averaging 1.9 fpm. The velocity in a sedimentation basin, however, is not uniform over the cross section, even though the inlet and outlet arrangements are designed for uniform distribution. The drag on the walls and floor results in zero velocity at these points and ex-

ceeds the average at other points in the basin. The velocity is not stable because of varying density of the water, eddy currents, and volume of sludge. These factors are important in the determination of the dimensions of the basins.

24. Sludge Storage and Cleaning

Unless sludge is removed continuously, allowance must be made in the basin volume for sludge accumulation between cleanings. In manually cleaned basins, coagulated matter may be allowed to accumulate until it tends to impair the settled-water quality, at which time the sludge is flushed out. Where the water is fairly turbid, the greatest depth of sediment is near the inlet end of the basin. There is no specified depth of sediment beyond which it should not be allowed to accumulate, but in the design of the basin an arbitrary depth is usually assumed as unavailable for settling.

As indicated previously, sedimentation basins which are not equipped for mechanical removal of sludge usually have sloping bottoms, so that when they are drained for cleaning, most of the sediment flows out with the water. Because the bulk of the material settles near the inlet end, the floor slope should be greater at this point. In some plants, sluice gates are arranged to deliver raw water to the sedimentation basin to flush out the sludge. The balance is generally washed out with a fire hose fitted with a small nozzle.

The time between cleanings varies from a few weeks, in plants that have short periods of settling and handle very turbid water, to a year or more, where the basin capacity is large and the water is not very turbid. Sometimes decomposition of organic matter in the sediment makes it desirable to clean a basin more often than would otherwise be necessary. Decomposition of certain types of sludge can be controlled by prechlorination or other chemical treatment.

25. Sludge Removal Devices

Sedimentation basins may be equipped with sludge collection and removal mechanisms to maintain volumetric efficiency and reduce the need to shut down for cleaning.

Circular tanks may be provided with rotating mechanisms driven by motors mounted at the center of the tank or, in some plants, by motor carriages running on the wall of the tank and pulling the arms around. The rotating apparatus—equipped with rakes or blades that travel slowly around an axis, just above the floor of the basin—is designed to push the sediment to the center of the basin, where it is flushed out with a small stream of water. The bottom of the basin itself is given a fairly steep slope toward the center to facilitate the movement of the sludge. Square tanks may be equipped with a similar mechanism, except that two of the arms are often provided with outriggers which sweep into the corners of the tank outside of the radius of the circular area and convey the solids in those corners into the region of the main arms.

Two types of sludge removal mechanisms are available for rectangular basins. One kind consists of a series of chains and sprockets, with the latter mounted at the top and bottom of the tank. Wood or steel cross members or flights are fitted between the chains. The flights scrape along the tank bottom, dragging the sludge to an outlet at one end. The second type of mecha-

nism, mounted on a carriage which travels along the wall of the tank, does not have wearing parts under water and is thus less subject to shutdown. The sludge blades may be lifted and inspected at will without emptying the tanks.

Removal equipment must be designed to withstand the highly abrasive action of the sludge. In presedimentation basins where sand and grit is a problem and in softening plants where lime sludge is removed, careful design of blades is highly important, and wearing parts should be located above the water line.

Where continuous sludge removal is practical, it is sometimes found desirable to return part of the sediment collected to the raw water entering the mixing basins in order to aid in coagulation and reduce chemical requirements. This practice is especially advantageous in softening plants, where the returned sediment aids greatly in carrying the softening process to completion.

26. Covers for Sedimentation Basins

In northern latitudes, the use of covers for sedimentation basins has been found desirable as a means of eliminating the interference caused by ice formation in the settling process and the consequent damage to basin walls and baffles. If treatment plants are located in built-up urban areas, covers are often beneficial in preventing pollution by wind carriage or by careless or irresponsible persons. Covers also are useful in avoiding wind disturbances and thermal stratification, but are rarely justified for these purposes alone.

Because of the short detention periods usually involved in present-day sedimentation practice, it is not often necessary to provide covers as a means of preventing algae growth. Although covers do offer many advantages, their cost is so great that their use has been confined principally to areas subject to serious ice troubles. It should be pointed out that where covers are used, roof spans as long as are consistent with good structural design should be employed, inasmuch as columns create undesirable turbulence in the water.

27. Suspended-Solids Contact Clarifiers

In recent years, water has been prepared for filtration in basins which combine mixing, flocculation, conditioning, clarification, and sludge removal in a single unit, where coagulation and flocculation take place in the presence of previously formed floc and there is a continual removal of excess solids from the bottom of the installation. An AWWA committtee report (*14*) lists eight manufacturers of this type of equipment and discusses its advantages and disadvantages.

Of particular interest is the compactness of multipurpose units, which—having high takeoff rates and being designed for specific capacities—require less space than conventional settling basins and may be less costly to install. Operating costs have varied from plant to plant. Some state authorities have not approved the use of these units to produce potable water, because of the low detention time, which may be as short as ¾ hr, but usually approaches 2 hr. The units have the further disadvantage of losing water in sludge removal, the amount varying from 1 per cent to as high as 10–12 per cent. Illustrations of several types of units are shown in Fig. 13–2 through Fig. 13–9 in Chapter 13, "Softening."

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Reprints of 'Water Quality and Treatment' Revision

As a new edition of *Water Quality and Treatment* will not be published for at least several years, reprints of this revised chapter will be distributed without charge to future purchasers of the current (second) edition of the book, which may be obtained from the Association for $5.00 per copy ($4.00 to members paying in advance). Reprints will also be made available for purchase at a later date. Further details will be announced in a future issue of the Journal.

AWWA Safety Manual

Part 3—Safe Working Practices

After several years of study, AWWA Committee A2.E—Safety Practices has prepared a manual of safety practices for water utilities. The document is divided into four parts, the first two of which were printed in the July 1955 issue, beginning on p. 637. Part 3, because of its length, is being published in several installments, the first appearing in this issue. When serialization is completed, the manual will be made available as a separate volume for easy reference.

Although most utility workers agree that the right way to do a job is the safe way, they do not concur on what constitutes the latter. It must be admitted that most jobs can be done safely in more than one way, depending on such factors as competence, experience, and alertness of the workers. An indefinite work pattern, in which each employee or crew is free to choose the work methods, however, will certainly result in confusion and an increase in injuries. Safe work procedures for all jobs should be established and standardized if the maximum benefits from an injury prevention program are to be attained. Standardization of safe work methods, together with adequate training and teaching programs—the proved way to reduce injuries—is the basic requirement for safety.

To aid in meeting this necessity, Part 3 was prepared by experienced water works safety directors, laboratory technicians, superintendents, and engineers. Although it is hoped that the procedures presented are acceptable to the majority of water utilities, it is expected that some improvisation will be called upon to cope with a wide variety of field conditions. Adopted changes in work patterns should be written into the work standards for the utility after having been carefully scrutinized for possible errors.

Section 1—General Safe Practices

Each person should consider his job carefully from the viewpoint of performing it safely and efficiently. The instructions presented in this section are intended to assist in developing safe work habits. It should be realized that the best set of safety rules ever written cannot make a safe workman, unless he is taught to think safety, act safety, and promote safety constantly.

Safety is a part of everyone's job; it is the duty of all employees to work safely, as well as efficiently. They should study the safety instructions and ask the foreman for clarification where the rules are not understood. Because the worker should do only those jobs in which he has been instructed and for which he can qualify, he has the right to question an assignment if his safety training does not fit him for it. He should always wear clothes suitable for the type of work at hand. Articles of apparel should be

changed as frequently as necessary to meet safety demands.

Signs should be carefully read and obeyed, for they give vital information affecting safety, often pointing out such features as safe load limits, the number of men allowed in hazardous locations, the time when equipment is unsafe to operate, and other important details. Zoning lines, such as safe storage limits indicated by lines painted on platforms and buildings, should also be respected. Storage spaces should not be overloaded or overcrowded, nor material stored where forbidden.

The water works employee must use his brains, eyes, ears, nose, and tongue. The job should be thought through before it is begun. Unsafe circumstances or unusual conditions of equipment should be looked for, as well as unusual noises in machinery and other places. Further, a man's nose can detect fires, fumes, and other indications of danger. If his brain, eyes, nose, or ears inform him of a hazard, he should use his tongue to request correction or to get help, if needed.

Fig. 3. Use of Protective Eye Goggles

Both workers are wearing protection against serious eye injuries from metal fragments.

Personal Protective Equipment

Furnishing and enforcement of use of personal protective equipment should be one of the primary steps in an accident prevention program. A

workman should not be asked to use a chisel or other impact tool on a hard, brittle material unless eye protection is furnished (Fig. 3). Hard hats are a requirement on most construction jobs and in some maintenance work where there is a danger from falling objects. Safety shoes and foot guards have often saved the toes and feet of men handling heavy objects or using such heavy tools as concrete breakers (see Fig. 4). The wearing of personal protective equipment, where specified, must be made mandatory.

Face and Eye Protection

The item of safety equipment with the widest variety of design is goggles. For protection of the eyes against impact, suitable spectacle or cup goggles and eye and face shields are available for almost any job. Because tests have shown that plastic equals glass in practically all respects, lenses of either type meeting ASA and federal specifications may be used for hazards from impact. Chemical goggles or acid hoods should be used when there is the danger of eye damage from heat or chemical action. In welding and in handling molten metals, the peril of infrared radiation may be present in addition to the risk of molten-metal splash. To reduce the radiant energy transmitted to the interior of the eye, filter lenses should be chosen by these grades:

Fig. 4. Use of Foot Guards

In addition to foot guards to protect against injury, the workmen are wearing goggles and hard hats.

1. Shade No. 3 for protection against glare or reflected light, spot-welding operations, or light brazing
2. Shade No. 4 or Shade No. 5 for light acetylene cutting and burning
3. Shade No. 6 for general acetylene welding, use by welder's helper, or arc welding
4. Shade No. 8 for heavy acetylene welding or cutting or very light arc welding
5. Shade No. 10 for arc welding up to 250 amp
6. Shade No. 12 for arc welding of more than 250 amp and for atomic hydrogen welding

7. Shade No. 14 for carbon arc welding.

Because welders must also chip and clean off the weld, they should wear spectacle goggles under their welding helmets. Although goggles and eye shields are available to fit over ordinary eyeglasses, those with prescription-ground safety lenses are more comfortable for the man who must wear eye protection the major portion of the time on the job. Often workers fail to see the need for eye protection. If the precise reason for their objection is found, it can usually be countered by education, logical persuasion, or personal appeal, plus supervisory example.

Fig. 5. Safety Precautions at an Emergency Job Site

The men in the ditch are wearing hard hats. Note how the compressor and barricade are used to block traffic.

Foot Protection

Well made work shoes with a steel box toe are available from a number

of manufacturers at slightly more than the cost of other good work shoes. This safety feature may also be obtained in most rubber boots. To obtain more protection from very heavy impacts, thick flanged and corrugated sheet metal foot guards are recommended (Fig. 4). With the flange resting on a firm floor surface, the foot guard should resist an impact of at least 300 ft-lb without sufficient deformation to damage the shoe underneath or injure the foot.

Hand Protection

Besides the ordinary hazards to the hands from friction, minor scratches, and bumps, there are those injuries caused by particularly rough, sharp, and hot materials, as well as chemically active substances. Hand leathers or a heavy glove or mitten of chrome-tanned cowhide, often reinforced with steel staples or wire, is usually used for protection against mechanical damage while handling such objects as lumber or rough castings. Asbestos or asbestos and fabric serve best to protect the hands from hot materials. Acids, alkalies, oils, solvents and other chemicals in handling and mixing processes require rubber, neoprene, or plastic gloves, depending on the substances.

Necessary wrist and forearm protection determines the style and length of a protective glove, unless a separate gauntlet is worn. It must be remembered that wearing hand protection around revolving machinery is dangerous.

Head Protection

Hard hats are made of metal, plastic-impregnated fabric, or fiber glass crowns suspended on an adjustable headband by fabric hammocks. They all are comfortable, water resistant, well ventilated, and have great strength against impact. Metal hats should not be used where there may be an electrical hazard. Hard hats should be worn by those endangered by tools or materials that could fall from higher elevations. Such protective aids are necessary in all trench operations (see Fig. 5). Between Aug. 1950 and Oct. 1953, there were 200 recorded incidents in which hard hats saved the wearers from serious injury or death.*

Respiratory Equipment

Respiratory hazards include: [1] nuisance dusts such as rock, cement, coal, wood, and flour particles; [2] dusts of toxic materials such as lead, arsenic, and fluorides; [3] mists and fumes from chemicals and heated metals; [4] vapors and gases such as chlorine, ammonia, and carbon monoxide; and [5] oxygen-deficient atmospheres resulting from depletion by chemical action or displacement by other gases or vapors. Atmospheric contamination causes respiratory effects ranging from mild irritation to death. Because some of the most lethal gases and atmospheric conditions give few clearly recognizable warnings to the unsuspecting workman, it is important to be aware of the possible air contamination hazard in all occupations so that the correct respiratory protection can be furnished.

It should be emphasized that adequate ventilation or elimination of the dangerous process is the preferred method of abating the peril of a respiratory hazard. If such a system is followed, the personal protective equipment will provide an extra factor of

* The incidents were recorded by the Turtle Club, c/o E. D. Bullard Co., San Francisco.

safety for the stray or reduced concentration of contaminants still present. This equipment should be available to effect shutoffs or for rescue in emergencies. In selecting specific respiratory protection for particular hazards, recommendations of the US Bureau of Mines should be followed.

Filter respirators. A filter respirator, essentially a mask made of a resilient material to fit the contour of the lower part of the face, will mechanically remove the dust fumes or mists for which the particular filter was designed as the wearer inhales (see Fig. 6). Filter units, which are quickly and easily replaceable, should be changed when it is found that breathing becomes difficult. Use of the correct filter for the air contaminant is important because of the wide variation in types and sizes of dust, mist, and fume particles.

Canister and cartridge respirators. Canister and cartridge respirators, including gas masks, utilize chemicals to neutralize or filter out the contaminant. Some canisters are designed to neutralize a wide range of contaminants. The factors which determine the safe length of time that one canister may be used are the amount of chemical in it and the concentration of the contaminant in the air. Few canister masks are approved for use in concentrations of more than 2 per cent for most gases. Because canister and cartridge respirators are usually held in readiness for emergency use, good maintenance, frequent inspection, proper instructions, and good physical condition are all greatly important. Gas masks should be used only when it is certain that there is adequate oxygen in the air to support life.

Supplied-air respirators. Supplied-air respirators consist of either a helmet or a face piece covering the nose and mouth to which air can be supplied through a hose from an uncontaminated source. The air can be furnished by a mechanical air compressor with pressure reducer, a low-pressure hand blower, or the lung action of the wearer. A supplied-air respirator is suitable for use in tanks or other close spaces, where work can be done near the air source.

Fig. 6. Application of Protective Coating

The workman is fully clothed, with no exposed body parts. He is wearing a respirator and safety goggles.

Air or oxygen breathing apparatus. With air or oxygen breathing apparatus, the user, carrying his own source of air or oxygen, can operate independently in any concentration of dust or gas or under any condition of oxygen deficiency. Some equipment of this type depends on compressed oxygen and compressed air, whereas some

use chemicals in a canister to generate oxygen from a reaction with the moisture in exhaled breath. Adequate instruction in the use of such apparatus is imperative.

Safety Belts

Safety belts are employed to provide steady support for men at work, as in window cleaning, as well as to stop them safely if they should fall. In the first use, the belt usually carries only a low static load, but in the second, the safety device may be subjected to many times the weight of a man. Although both leather and webbing are used in safety belts, it has been found that the latter will sustain much greater impact loads. In using safety belts, the length of free fall should be held to an absolute minimum, because of the internal damage which may be done by a sudden jolt. To prevent such injury, shock absorbers are available for use with safety belts and lifelines. Such protective gear should be used by men working in high places, from insecure platforms, or with other unsuitable footing.

First Aid

Although it may seem that first-aid training has little or no bearing on the prevention of injuries, it has long been known that men versed in rendering first aid are less susceptible to accidents than those not so prepared. The American Water Works Service Co., Philadelphia, quite convincingly showed the effect of first-aid training on accident rates through a study of 64 utilities (see Table 8).

The results of studying first aid are so favorable that it is only fair to the employee, as well as to the utility, to insist that workmen take the Red Cross first-aid safety course. This should be followed up constantly with short refresher sessions and supervised practice periods, so that no employee will ever be working out of reach of some individual prepared to take care of an injury in the best possible way until the arrival of a physician.

Any injury, no matter how slight, should receive prompt first-aid attention, and, if serious, it should be treated by a physician. If there is absolute certainty that movement will not be harmful to the casualty, he should be assisted to the aid station or hospital, but, if the injury is serious, or there is any doubt whether movement would aggravate the condition, medical assistance should be brought to the patient.

TABLE 8

First-Aid Training and Accidents

Personnel With First-Aid Training %	Frequency Rate	Severity* Rate
0	25.88	1,407
1–10	24.59	286
11–50	22.83	106
51–100	8.20	60

* 1954 standard.

The medical staff for the utility personnel should establish standing orders for first-aid procedure. Where this is not done, each worker should be given detailed first-aid instructions with periodic refresher courses. A first-aid instruction chart and a well equipped and maintained first-aid chest should be prominently displayed. Whenever possible, standard first-aid equipment should be supplemented with special

material to meet particular needs. Oxygen is not usually considered part of first-aid supplies, but it should be available in laboratories where, for example, aniline poisoning may occur. If it is possible that certain toxic substances may be swallowed, specific antidotes should also be available.

First-aid kits. First-aid kits should be assembled under the direction of a physician who understands the needs of the job, but if that is not possible,

TABLE 9

*Contents of First-Aid Kit**

Material	Units	Quantity per Unit
Adhesive bandages	2	16
Burn ointment	2	2
Ammonia inhalants	1	10
Antiseptic swabs	2	12
Eye-dressing packet	1	3
2-in. bandage compress	2	4
4-in. bandage compress	1	2
Tourniquet, forceps, and scissors	1	1
Triangular bandage	1	1
Wire splint	1	1
Gauze bandage 4 in. × 6 yd	1	1
Gauze compress 24 in. × 72 in.	1	1
4-in. scissors	1	1
Red Cross First-Aid Textbook†		

* A stretcher should also be available.
† Published by American Red Cross, New York.

a fully equipped "16-unit" first-aid kit should be provided for each 25 persons employed. Periodic inspection should be made to insure that kits are kept supplied with the materials listed in Table 9.

New Employees

The foreman should consider any person recently employed or transferred under his authority as a new man, and should:

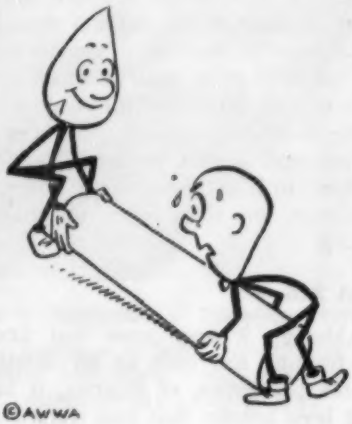
1. Instruct him thoroughly in the job
2. Inform him about plant safety requirements, proper clothing, safety goggles, and other important items
3. Place him for a time under the charge of a safety-minded employee for instruction; give him an opportunity to adjust to safe work procedures
4. Check to determine if he is doing the job safely
5. Reinstruct, if necessary.

Lifting or Lowering

1. The right way to lift by hand is to:

a. Get a good footing

b. Place feet about shoulder-width apart



c. Bend at the knees to grasp the weight

d. Keep the back straight

e. Get a firm hold

f. Keep the back as upright as possible, lifting gradually by straightening the legs

g. Turn the whole body, including the feet, rather than twisting the back

to change direction while holding a heavy weight

h. Get help when a load is too heavy or bulky for one person to lift comfortably.

2. A worker should use mechanical handling equipment whenever possible, and should:

a. Check the load against the capacity of the equipment

b. Use safe slings properly applied; never use frayed rope or wire, which should be destroyed

c. Stand clear during lifting with mechanical equipment

d. Wear a hard hat for construction work or whenever there is danger from falling objects.

3. When lowering anything, apply the same rules used for lifting.

Wheelbarrows

The worker should load a wheelbarrow only to the extent of his capacity to handle it and should always push instead of pull. He should:

1. Place the load as far forward as possible so that the wheel will carry the bulk of the weight

2. Not underestimate his and the barrow's weight when using planking or runway

3. Keep pneumatic tires properly inflated

4. Wear gloves in close quarters or have the barrow handles equipped with hand protectors.

Hand Trucks

Hand trucks should be loaded properly to prevent materials from tipping. The worker should:

1. Refrain from riding on trucks or engaging in horseplay

2. Proceed slowly, and estimate the clearance, especially on platforms, to prevent overturning

3. Use metal hand protectors on the handles

4. Watch out for other employees to prevent a mishap

5. Report for repair any mechanical defect.

Falls

The use of a safety belt is required on a roof which slopes over 15 deg or presents hazardous footing. In strong winds on high elevations, such as on towers, stacks, platforms, and tanks, the safety belt should be fastened. The worker should:

1. Walk, never run, especially on stairs

2. Keep aisles and work areas clear of obstruction

3. Develop safe habits; be neat and orderly in his housekeeping; wipe up oil and grease spots

4. See where he is walking when carrying objects

5. Keep at least one hand on hand rails when using stairs or ramps

6. Provide himself with a flashlight when moving around in the dark

7. Refrain from climbing over obstructions, and use the safest route available

8. Descend slowly from a vehicle, whether it is in motion or not; drive carefully, requiring that all passengers be seated safely and that no one stand or hang on the outside.

Scaffolds

Safety scaffold planks are either 2 in. thick, 10 in. wide, and 8 ft or 12 ft long, or 3 in. thick, 10 in. wide, and 15 ft. long. The planks are straight-grained spruce, painted 12 in. on each end. There should be a maximum overhang of 8 in. on every scaffold. In the absence of safety planks, only Class A lumber is to be used for any span or

temporary decking of supports. Recommended species of wood are Douglas fir, southern pine, Norway pine, and Tamarack and Sitka spruce. Planks should have cleated bottoms to prevent slipping on tubular scaffolding. Only these types of scaffolding are advisable:

1. Carpenter's horses decked with safe planks; (Chairs, boxes, barrels, or other improvised supports are not safe).
2. A frames (do not stand on the top rung), preferably two planks wide and two planks thick for heavy loads (A ladders one plank wide are permissible).
3. Tubular steel or aluminum scaffolding, safety-plank decked, with needed toeboards and handrails.

These safety practices should be followed:

1. All material assigned for scaffolds should be inspected upon installation and thereafter every 4 months.
2. State safety orders should be complied with when scaffolds are built.
3. Every scaffold and its supporting members should be designed to carry a given load with a safety factor of at least four.
4. A handline should always be used to raise or lower tools and materials.
5. Workmen should not jump on or off a scaffold.
6. Adequate signs or barriers should protect scaffolds against moving objects, such as hand or power trucks.
7. A scaffold should not be used for any other purpose than that for which it was designed.

Swinging Scaffolds

1. Hoist the scaffold 1 ft off the ground and test with four times the working load before use.
2. Fasten the scaffold to a building wall to prevent sway.
3. When in use, do not combine two swinging scaffolds by a bridge.
4. Do not permit more than two men on a swinging scaffold at the same time.
5. Keep excess scaffold rope coiled in a drum on the ground.
6. As additional protection, use a life belt and a safety line when working from a scaffold.
7. Work only within the convenient reach of a scaffold.
8. Permit only experienced workmen to erect and remove scaffolds.

Ladders

1. If straight and extension ladders are not chained or roped at the top, they must be held by someone
2. Snap spreaders should always be engaged on stepladders.
3. One person should have full charge of ladders and be responsible for their maintenance.
4. All ladders should conform to ASA specifications.

Willing Water Says:

Accident prevention requires a constant check on working methods.

5. Stepladders should replace straight ladders of short length where possible.

6. Ladders should be tested for defects every 4 months, using the ASA method. The rungs should be tried with a wood mallet.

7. Before a ladder is used, it should be carefully examined for possible defects of the side rails and rungs. If the rope on extension ladders is not in first-class condition, it should be replaced immediately.

8. Ladders should be centrally stored and protected from the weather.

9. Extension ladders should not be taken apart in order to use two sections separately.

10. Ladders found too defective to be repaired should be destroyed. Those with weak, cracked, or missing rungs, or weak or cracked side rails should be repaired or destroyed. Homemade ladders should not be trusted, because the quality of material and workmanship is usually low.

11. Ladders should not be painted except for necessary identification marks because defects in wooden ladders may be concealed by the use of paint. Instead, several coats of linseed oil should be applied to new ladders.

12. If a ladder is placed over a doorway, the latter should be roped off and warning signs erected.

13. Workmen should always face ladders when ascending or descending.

14. Only one man should be on a ladder at one time.

15. Stepladders should not be used as a straight ladder.

16. The top of a stepladder should never be used as a platform on which to stand.

17. Employees should ascend only to the third rung from the top of a straight or extension ladder, and the second step from the top of a stepladder.

18. Straight ladders should be so placed that the distance of the base of the ladder from the wall is 25 per cent the length of the ladder.

19. Nonskid ladder feet should be placed on straight ladders used on a hard, smooth base such as concrete. Spiked ladder feet should be employed on a soft or loose base such as ground or earth. In other words, proper nonskid ladder shoes should be used on all ladders.

20. A level, stable base should be established for all ladders.

21. Ladders should not be used as skids, braces, or scaffolding members, or for any purpose other than that for which they are intended.

22. The habit of being sure a ladder is safe before using should be developed.

Stairways

1. Never run on stairs, take enough time to be safe, and use the hand rails provided.

2. Keep stairs free from grease, other wet or slippery substances, or conditions capable of causing a fall.

3. Inspect hand rails frequently to make sure they are free of splinters or loosened nails and are not working loose from moorings.

4. Never store tools, supplies, or other materials on stairways. Keep them neat and clear to serve safely.

5. Always watch the steps just ahead. Never carry anything in such a way that vision is obstructed.

6. Take but one step at a time.

7. Be sure that stairways are properly lighted when used at night or on dark days.

8. Look carefully in the direction of movement. If attention is distracted, stop until vision can be directed back.

9. Report all loose treads, risers, and hand rails for immediate repairs.

Walkway Aisles

1. Temporary walkways, at least two planks wide, should be cleated underneath to prevent spreading.

2. The span between bearing points of planks 2 in. thick and 8 in. wide should not be over 8 ft, and the planks should be tested before being placed in use.

3. Semipermanent walkways over trenches or openings should be at least three planks wide, with suitable guardrail protection.

4. Aisles and walkways should be kept clear of obstructions.

Handrails

For handrail safety, the following procedures are imperative:

1. Construction should be substantial and durable. No guard or railing should be installed or kept in use that can be broken, collapsed, or displaced by the weight of a man's body lurching against it. The top rail should withstand a 200-lb load applied in any direction.

2. Hand rails for stairs should be 30–34 in. high, and consist of three rails. Toeboards should be ¼ in. above the floor. Railings around openings should be 42 in. high.

3. The use of railings without a midrail should not be permitted.

4. Toeboard spacing above the floor may be increased to ½ in. where snow or hazardous materials may collect.

5. Wood railings should be built of sound materials. Handrails and midrails should be dressed on all four sides and the edges of the handrail beveled.

Machine Guards

1. Protective guards should not be removed during progress of work, and should be kept in repair.

2. Projecting shaft ends should present a smooth edge and should not project more than one-half the diameter of the shaft, unless guarded by a nonrotating cup or safety sleeve.

3. All projecting keys, setscrews, and other unguarded projections of moving parts should be cut off and

made flush or guarded by a metal cover.

4. Shaft couplings should not present a hazard from bolts, nuts, setscrews, or other projections on revolving surfaces. Shaft couplings should be hood guarded.

5. Where oiling must be done frequently, openings with hinged or sliding, self-closing covers should be provided.

6. Where oiling must be done while a machine is in operation, extension fit-

tings should be used to place the operator out of danger.

7. Guards should be designed not to interfere with the usual machine operation, but to give maximum protection to the operator.

Running and Walking

1. Do not run except for extreme emergencies.

2. Do not run or jump across ditches, scaffolds, or platforms.

3. Do not jump into a trench, but use a ladder.

4. Practice walking with open eyes and cautious feet.

5. Never run or hurry upstairs or downstairs.

6. Do not jump over piles of material, but walk around them instead.

Section 2—Hand Tools

Hand tools, used by practically everyone, are responsible for about 7–8 per cent of all compensable injuries, according to the National Safety Council. An AWWA task group reported in 1953 that hand tools were the cause of 26 per cent of all injuries to distribution system employees.* These statistics should impress both employees and supervisors with the need for learning the proper care and handling of tools. By following the proved safety precautions presented in this section, a major source of injury can be reduced.

Basic Rules

1. Always select the appropriate tool for the job, never a makeshift.

2. Check the condition of a tool at frequent intervals, and repair or replace it, if defective.

3. Avoid using tools on moving machinery; stop the machine before making adjustments.

4. Check the clearance at the work place to make sure there is sufficient space if the tool should slip.

5. Have good support underfoot, so that there is no hazard of slipping, stumbling, or falling.

6. Protect hands by wearing gloves in confined places, except when using hammers. Do not wear rings.

7. Carry sharp or pointed tools in covers, or be sure they are pointed away from the body in case of a fall.

8. Wear eye protection when using impact tools on hard, brittle material.

9. After using tools, wipe them clean and put them away, thus keeping the work place orderly.

10. Do not lay tools at top of stepladders or on other places from which they could fall on someone below.

11. Learn and use the right way to work all hand tools.

12. Use tools made of nonsparking material where fire is a hazard.

Axes and Hatchets

1. Keep axes sharp.

2. See that overhanging brush or limbs are cleared away and that no nearby obstructions can deflect the axe.

* Journal AWWA, Vol. 45, p. 952 (Sep. 1953).

3. Place the feet firmly, being sure the axe can swing naturally, and keep both hands on the handle. Be certain that other persons are away from danger.

4. Swing the axe like a baseball bat —not like a pendulum—away from the body and toward the place of cutting.

5. When the axe is not in use, place it in plain view, a safe distance from the work area with the blade down or flat, never up. After work, store the instrument in a rack or case.

6. To carry a double-bit axe properly, grasp it by the handle just back of the head, with the blades vertically beside one leg. Carry a single-bit axe the same way, with the blade down or pointed away from the leg.

Chisels and Punches

1. Use only tools in good condition; never use a burred chisel or a hammer with a mushroomed head.

2. If the chisel is not properly tempered or sharpened for the job, or if it is defective in any way, return it to the tool room.

3. Wear goggles to protect eyes from flying particles.

4. Hold a cold chisel between the thumb and forefinger, with the palm up; if the tool is gripped in the fist, a blow that misses the chisel head is almost certain to result in painful and sometimes permanent injuries to knuckles and hands.

5. Do not attempt to hold a chisel if hands are numb with cold, as control of the chisel may be lost.

6. Never grip a chisel by hand when another person is swinging the hammer or sledge; use a holder.

7. Protect other persons from flying chips by placing suitable screens. Two men chipping on the same material should work back to back.

8. When using a bull chisel, hold it with tongs, never with hands. Take a position that is clear of the swing of other hammers and to one side of the arc of swing of the one being wielded.

9. Never push wood chisels toward any part of the body.

Files

Because the sharp tang of an unprotected file can make a painful and disabling wound, a supply of good file handles should be kept on hand. These points also are important to safety:

1. See that there is a securely fitting, substantial handle on each file used.

2. If any files have particularly sharp-pointed tangs, round them off to avoid injury when reaching into the tool box.

3. When filing work close to the chuck in a lathe, change hand positions so the extended arm or clothing will not be caught in the chuck jaws

or dog. Short-sleeved shirts are usually recommended for such work.

4. Never hit a file with a hammer, because pieces of the hardened steel are likely to fly off.

5. Do not make a center punch or a chisel out of an old file, for the metal is too brittle.

6. Do not use a file as a pry, because it breaks easily, and may send pieces of jagged metal flying about.

7. Do not carry a file in a pocket unless a handle is over the tang, because in case of a fall the tang might cause injury.

8. Keep a file clean and sharp to minimize its chance of slipping and causing a wound.

Hammers

1. Select a hammer of a type and weight suitable for the job. Make sure the head is wedged securely on the handle and that neither is chipped or broken.

2. Keep the hammer clean and free from oil or grease to prevent slipping which might mean a dangerous loss of control.

3. When using a hammer, grasp the handle firmly near the end, watch the place of impact, and strike a true blow.

4. Always hammer with the tool's face, which is specially hardened for this purpose.

5. In starting a nail, hold it near the head to prevent smashed fingers.

6. Do not use a hammer with a hardened face on a highly tempered tool such as a drill, file, or die, because small chips may break loose with high velocity.

7. When drawing nails that are hard to remove, place a wood block under the hammer head to increase the leverage.

Picks

1. Make sure that the handle of a pick is smooth, free from splinters, and straight, and that it fits tightly in the head.

2. When swinging a pick, make sure no one is near enough to be hit.

3. Avoid striking toward or close to the feet.

4. Leave adequate clearance in trenches for the swing, so that it does not strike unintended objects and deflect toward the wielder.

Saws

1. Keep the saw sharp and clean, and the teeth properly set.

2. Use a crosscut saw for cutting across the grain, a ripsaw for cutting with the grain.

3. Start the cut with two long, slow strokes toward the body, guiding with the thumb; then, remove the hand before beginning work.

4. To prevent sticking, keep the blade true with the cut: in wet or gummy wood, a little oil or paraffin may help.

5. Do not "ride" the saw; if it doesn't cut well, sharpening or setting may be needed.

6. If one knee is used to steady the work, watch the balance carefully.

7. Handle saw teeth carefully, for they can make a worse cut than a sharp knife.

Screwdrivers

1. Never use screwdrivers with split or splintered handles.

2. Always use a screwdriver that fits the screw.

3. Dress the point if it is worn, bent, or broken.

4. Use an awl, auger, drill, or driven nail to start each screw; on rough work use a hammer.

5. Never hold work in the hand, but place it on a flat surface or in a vise.

6. Use screwdrivers with insulated handles for electrical work.

Shovels and Spades

1. Inspect the tool to see not only that it has a strong, smooth handle and grip, free from splinters, checks, and splits, but also that the blade is smooth, sharp, and free from twist.

2. When shoveling, be sure there is plenty of clearance between the user and others to avoid striking them with the tool or material. When working in a ditch, be especially careful to keep a good clearance both before and behind.

3. Use the ball of the foot, not the instep, to press the tool into clay or other stiff material; steel footirons will help protect the instep.

4. Avoid strains when digging and lifting by using the leg muscles as much as possible. Be sure of footing and balance when shoveling materials.

5. Never throw or toss a shovel or spade toward another person, but pass it over with the handle forward.

6. Never leave a shovel or spade where others may stumble over or strike against it. Hang it up, if possible, or place the blade securely in the ground or some material, or stand the tool in a corner.

Wrenches

1. Use wrenches that are the right type and size for the job. Never use a pipe or other extension on the handle to get more leverage.

2. Use only wrenches having jaws in good condition; keep pipe wrench and chain tong jaws sharp and clean. Inspect chain links closely for defects.

3. Never use a shim to make the wrong-size wrench fit a nut.

4. Do not use a wrench as a hammer.

5. Always place the wrench on the nut so that the pull on the handle tends to force the jaws further onto the nut. (Move the handle in the direction in which the jaws open.)

6. Pulling on a wrench is safer than pushing, but if the latter is necessary, keep the knuckles out of danger.

7. To avoid falls, see that the footing is good before applying pressure.

8. Do not place a pipe wrench on a nut to be reused.

9. Adjust a pipe wrench to bite the work near the middle of the jaws so that there will be teeth in front if the wrench slips.

Section 3—Portable Power Tools

Portable Electric Hand Tools

Although shock is the chief hazard from electrically powered tools, power and speed are also dangerous. Electric-flash burns, falls caused by a minor shock, lethal shocks, and stumbling or tripping over cord may be caused by electric tools.

The power line should always be disconnected before accessories are changed, and guards should be replaced or put in correct adjustment before use. Electric tools used in wet areas or in metal tanks expose the operator to conditions favorable to the flow of current through his body, particularly if he is wet with perspiration.* Only tools listed by Underwriters'

* In damp locations the use of low-voltage equipment, not exceeding 32 v, is recommended.

Laboratories should be used. Most shocks are caused by the failure of insulation between the current-carrying parts and the metal frames. Because such deterioration is harder to detect than worn or broken external wiring, frequent inspection and thorough maintenance is needed. Care in handling the tool and frequent cleaning will help prevent the wear and tear which cause defects.

Insulating platforms, rubber mats, and rubber gloves provide an additional factor of safety in wet locations. Grounding of portable electric tools provides a positive way of safeguarding the operator. If there is any defect or short inside the tool, the current, drained from the metal frame through a ground wire, does not pass through the operator's body. Electric tools having a third ground wire built into the cord are recommended or required by many codes. This wire may terminate in a jack, battery clip, or a special three-prong receptacle in the wiring system. The last device eliminates the possibility that the operator will forget to attach the ground wire.

These precautions should always be taken when using electric hand tools:

1. Keep tools in safe condition, cleaned, oiled, and repaired.
2. Ground the tool when in use.
3. Use only approved and inspected extension cord.
4. Examine both the cord and connection carefully before use.
5. Because cords on the floor create a danger of stumbling or tripping, suspend them over aisles or work areas, where possible.
6. Avoid hanging an extension cord over nails or other sharp edges, allowing it to become kinked, or leaving it where a vehicle may run over it.
7. Protect the cord against contact with oil, hot surfaces, and chemicals.
8. Never patch any serious injury to cord insulation with tape; shorten the line or get a new one.
9. Wear goggles or a face shield while using electric hand tools if there is any danger of flying particles.
10. In the presence of flammable vapors, or gases, use pneumatic hand tools rather than electric ones.
11. Store extension cords in a clean, dry place where they can lie loosely coiled.
12. Do not under any circumstances allow a flexible shaft of a portable power tool to form a loop, as this will make a knot, jerking the tool out of the operator's hand.
13. When using a portable grinder, always wear goggles and keep out of line with the wheel.
14. When using portable grinders or buffers on toxic material such as lead, zinc, or brass, use adequate respiratory protection.
15. Do not wear gloves or loose clothing when using portable power tools.
16. Do not insert nails or other objects in the ventilating openings to

Willing Water Says:

Instruction and safe practices insure greater freedom from accidents.

stop the fan while tightening the chuck or performing any other operation.

17. Handle the tool carefully to avoid dropping it.

18. Do not use the cord as a line to raise or lower the tool from one elevation to another.

Pneumatic Tools

The same danger of tripping or stumbling is presented by an air hose as by an electric cord. Persons or material accidentally striking the hose may unbalance the operator or cause the tool to fall from an elevated location. Lying on the ground, an air hose should be protected against vehicles and pedestrians by two boards laid on either side of it or by a runway built over it. It is preferable, however, for the hose to be suspended over aisles and work areas.

Accidents sometimes occur when the air hose, becoming disconnected, whips about. A short chain attached to it and the tool housing will prevent such a hazard if the coupling should break. The hose should be kept away from oil and sharp objects which may weaken or cut it. The following points should be noted:

1. In operating portable air drills or reamers, do not under any circumstances wear gloves or loose, bulky, or torn clothing.

2. Keep tools in good condition and be especially careful that bits are ground correctly with uniform flutes and proper clearance.

3. Avoid feeding the machine too fast, in order to prevent the bit from sticking.

4. Place the machine straight in the hole; if tipped, the bit is almost certain to stick.

5. Have two men operate the larger tapping machines.

6. Install and maintain safety setscrews on all shaft collars.

7. Be particularly careful to see that all shaft collars are kept tight while tapping machines are in operation or when they are being carried to and from jobs.

8. Wear toe guards at all times when operating pneumatic tampers or jackhammers.

9. Wear eye protection when operating pavement breakers, chippers, buffers, or grinders.

10. Do not under any circumstances point a portable pneumatic tool at anyone.

11. Do not use compressed air to dust off the clothing or any part of the body. Such a practice is dangerous, because the air may enter the tissues or a body opening and cause serious consequences.

12. Check all hose clamps routinely for tightness.

Metalizing and Sandblasting

1. In operating a metalizer, keep as much skin surface as possible protected by clothing against the deposit of free metal discharged from the gun.

2. Wear eye and face protection at all times when the metalizer is in operation.

3. Wear approved respirators when toxic metal fumes are being discharged from the operation.

4. Keep the sand blast booth closed while blasting is in operation.

5. Wear a face mask assembly with forced air supply at all times when blasting. Only workers properly appareled should be admitted to the work booth.

Grinding Wheels

Probably the most common power tool in industry is the abrasive grinding wheel. Because it is used indiscriminately by many persons, frequent injuries result from lack of training, ignorance of the hazards, and incorrect setup and operation. Choice of the right wheel and speed of rotation are important considerations in any grinding job. Consult the wheel manufacturer for detailed recommendations. These admonitions should be heeded:

1. Apply work gradually, giving the wheel an opportunity to warm up slowly.
2. Never operate a wheel that is loose on its spindle, out of balance, or nicked or cracked.
3. Never allow a grinding wheel to stand partly immersed in water, for the water-soaked portion may throw the wheel dangerously out of balance.
4. Keep the tool rest as close to the wheel (not more than $\frac{1}{8}$ in. away) as possible without touching it; adjustment should be made when the wheel is not in motion.
5. The tool rest should be at or slightly above the center line of the wheel.
6. Where much pressure is required, grind the ends of heavy objects against only the face of the wheel.
7. Be aware that a glove may be caught and draw the hand into the grinder or buffer.
8. Wear goggles or a face shield on all grinding or buffing operations.
9. Avoid striking the side of the grinding wheel, because a sudden blow could cause the development of a fault which might result in a broken wheel.
10. Report immediately any grinding wheel that seems to be unsafe.
11. Do not grind on the side of the wheel at any time.
12. Do not open guards to expose wheels or nuts.

Soldering Irons

1. Keep hot soldering irons away from woodwork or other flammable material; set the tools on fireproof racks or holders when not in use.
2. Form the habit of turning off electric soldering irons every time the work place is left.
3. Never test the temperature of a soldering iron by holding it close to the face, as just one slip could be permanently disfiguring.
4. Avoid snapping or throwing surplus solder from the iron or wiping it on a trouser leg; keep a prepared pad handy for this purpose.

Section 4—Storerooms and Stockrooms

The safe and efficient operation of a storeroom, stockroom or other storage facility requires that the premises be maintained in a safe and orderly condition at all times. In other words, the principle of good housekeeping must prevail. Every precaution must also be taken to prevent injuries to employees while handling the stored materials. The safety rules presented in this section should be carefully observed.

Good Housekeeping

1. Keep all aisles and walkways clear. Passageways should be of sufficient width to permit the transportation of materials to and from storage (see Fig. 7).

2. Keep passageways clear to permit access by fire-extinguishing equipment.

3. Keep floors clear of all loose objects and free of water and oil.

4. To minimize fire hazards, do not permit waste paper, scrap lumber, or other waste material to accumulate on the premises.

5. Clearly designate storage areas and aisles by painted white lines on the floors (Fig. 8).

Proper Storage

1. Avoid overfilling storage bins; the material should not protrude into the aisle.

2. Do not store round objects at an elevation unless they are completely contained in a bin or box.

3. Do not store materials above floor level without providing at least a 4-in. toeboard on the shelves.

4. Store glass, glassware, and other fragile material in readily accessible locations for easy handling.

5. Be certain that materials are stacked properly; always pile them on a firm, even foundation. Do not permit the stacks to reach a hazardous height. When possible, crosstie the tiers in the piles for mutual support.

6. When storing heavy materials in buildings, stay within the safe load limit of the floors.

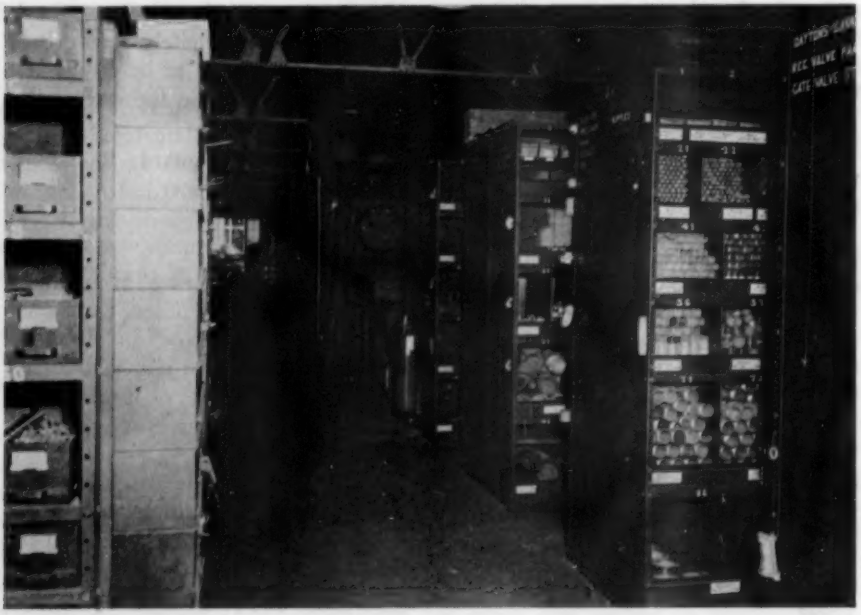


Fig. 7. Storage Bins

The aisles are clean and clear of obstructions. Fire extinguishers are readily accessible. The bins are numbered and labeled.

Safe Handling

1. Require warehouse employees to wear gloves, especially when handling wooden crates or metal containers; safety shoes are also recommended.

2. When uncrating materials or opening boxes or barrels, remove all metal straps and projecting nails, or bend them out of the way before actually starting the job of unpacking.

Handling Drums

1. Wear gloves when handling drums.

2. Keep hands at top center while rolling drums; to change direction, grasp the chimes and apply force.

3. Upending a full drum that weighs over 200 lb is a two-man job. They should stand with the container between them, grasp both chimes, and

Fig. 8. Water Utility Stockroom

Every article is neatly arranged and stacked. The painted floor lines are helpful for dividing the storage and aisle areas.

3. Avoid overloading hand trucks; balance the load carefully to avoid too much strain on the operator. Keep trucks in good repair.

4. See that all trucking skids and runways are securely fastened before using; place pins in the dock plates to prevent shifting.

lift one end while pressing down on the other. As the drum is brought to balance, they should release the bottom and straighten up with the drum. For a man to upend a drum that weighs less than 200 lb, he should stand close to the top end of the drum, place his feet close together, grip the underside

of the drum end, with hands about 8 in. apart, bend his knees so that his hips are lower than his shoulders, and apply the lifting effort with his legs.

4. To tip a drum standing in the open, grasp the nearest chime with both hands, push the drum to a balance, and then ease it down; a rocker type of drum tilter may be used.

5. Slide drums endwise down skids.

6. Use a parbuckle to pull drums up skids if the work must be done alone.

7. To loosen or tighten a bung, always use a proper bung wrench with a long handle, never a pipe wrench.

Power Trucks and Fork Lifts

1. Before using a truck, try out the brakes and be sure the truck is in good operating condition.

2. In crowded passageways, and when approaching intersecting aisles, drive slowly and cautiously.

3. Face in the direction of travel and be alert for danger, particularly when backing up.

4. When leaving a truck, be sure to shut off the power and remove the switch key or control handle.

5. Be sure that people can hear the truck's warning signals, but use them only when necessary.

6. Keep a safe stopping distance from other trucks or pedestrians; always give the latter the benefit of any doubt, as they may be deaf.

7. When approaching an elevator, bring the truck to a full stop at least 6 ft from the gate and set the brakes. Ring for the elevator, and wait until it comes to a complete stop before moving the truck.

8. Be sure the total weight of truck and load does not exceed the safe capacity of the elevator.

9. Insist that loads be stacked or trimmed for proper clearance before hauling.

10. Keep to the right of aisles and permit no one to ride on truck or trailer.

11. Do not allow any tampering with the truck mechanism except by authorized maintenance and repair men.

12. Do not ride in a truck whose control mechanism is installed in the tongue, for such placement indicates the vehicle was not designed to carry a person safely.

Section 5—Vehicle Driving

1. Every vehicle should be in safe operating condition, which requires satisfactory brakes, lights, windshield wiper, horn, muffler, steering mechanism, tires, and a gastight exhaust pipe.

2. Tire chains should be available for hazardous road conditions.

3. Trucks should be equipped with flares and flags required by local law, or, in the absence of such legislation, recommended by good practice. Suitable lights and reflectors to identify the outline of the truck should also be used.

4. Vehicles should not be overloaded, nor should they be loaded in such a manner that vision is obstructed. Appropriate flags should be available to identify objects extending beyond the bed of the truck.

5. The driver of the vehicle should know and observe local traffic regulations.

6. The driver should be "checked out" on the vehicle which he is to drive.

7. The driver should have the option of refusing to drive unsafe vehicles. In return, realizing that the quality of his driving will reflect either credit or discredit to the organization, the driver should assume a sense of responsibility.

8. The operator should be instructed in the use of the accident forms his truck should carry.

9. Each vehicle should be provided with suitable forms for reporting necessary repairs to the vehicle.

10. All vehicles which are used after daylight hours should be equipped with adequate blinker warning lights, located to be visible to traffic from either direction.

11. These general rules should be followed:

a. Always be able to stop in the assured clear distance ahead.

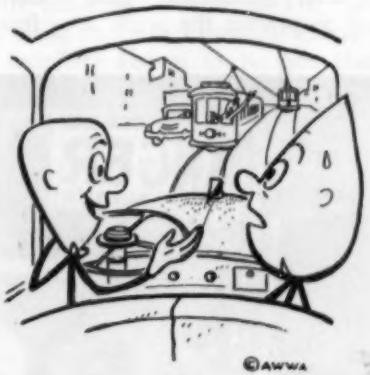
b. Always signal for changes of direction and stops.

c. At night always use low-beam lights when meeting or passing another vehicle.

d. Do not wear dark glasses for night driving.

e. Do not drive at a speed so great that it would not be possible to stop in the distance illuminated by the headlights.

f. Concentrate on driving: do not create hazards by absentmindedness.



g. Always yield the right-of-way.

h. Never forget that it is the careless other driver who causes accidents; stay out of his way.

i. Do not transport employees on trucks unless removable plank seats are installed. Do not allow men to stand on the running board or bed of the truck.

Section 6—Working in Manholes

Underground structures, such as valve and meter manholes and vaults, may be subject to air contamination. Records show there has been loss of life in manholes contaminated by gas from a leaking gas main or by methane from decaying organic matter. In one accident, a man lost his life in a valve manhole with a soil floor because substances (such as vegetable matter) in the subsoil depleted the oxygen in the air to a point at which animal life could not exist. Do not enter an underground structure without first assuring that the air is safe. Follow these precautions:

1. Proper tools should be used for the opening of the manhole or vault and the handling of the cover to prevent foot and back injuries. A suitable tool for opening manholes is a hand hook made of round steel rod

(½ in. diameter) at least 24 in. long. The hook, bent at a right angle to the shaft, should be about 4 in. long. The grip on the opposite end should be large enough to fit the hand and be in the same plane as the hook to permit the tool to lie flat when not in use.

2. Every precaution should be exercised to protect the work area from traffic hazards (Fig. 9). Barricades, signs, and lights should conform to all local and state regulations to provide adequate warning to traffic (see Sec. 14).

Fig. 9. Barricade Around Manhole

The metal fence and warning signs provide protection for the workman. As recommended for safety, he is wearing a hard hat. His helper and special equipment are not shown.

3. The absence of harmful or toxic gases in an underground chamber should be ascertained by approved equipment and methods before personnel are permitted to enter.* No manhole should be considered safe until it has been demonstrated to contain sufficient oxygen to sustain life or until fresh air is introduced mechanically. Oxygen deficiency may be determined by a safety lamp. The flame is extinguished when the oxygen in the air is at or below 16.25 per cent. Normal air contains about 21 per cent oxygen. First effects of oxygen deficiency usually occur at a concentration of 15 per cent.

4. Adequate and efficient ventilation should be provided to insure a sufficiency of fresh air during the periods

* Consult "Mine Gases and Methods for their Detection," Circular No. 33. US Bureau of Mines, Washington, D.C. (1948).

in which personnel are required to be within a vault or manhole. Where a blower is used for this purpose, the discharge end of the hose should be placed near the bottom of the manhole to force the air up and out.

5. Suitable measures should be taken to prevent surface water or debris from accidentally entering the vault or subsurface area while work is in progress.

6. Proper shoring and bracing should be used to prevent cave-ins while vaults or similar openings are under construction (see Sec. 9).

7. Tools should never be used or left in such a manner as to endanger the safety of personnel. Because falling tools are a distinct hazard, subsurface workers should always wear hard hats.

8. Mechanical lifting aids should be used to raise, lower, or suspend heavy or bulky material to men working in manholes or vaults.

9. A ladder should always be used for entering or leaving a manhole, vault, or pit.

10. Smoking should not be permitted in or about a manhole unless it is definitely known to be free from flammable gas.

11. A helper should be stationed at the manhole entrance at all times.

12. The helper should be trained to apply artificial respiration. He should have immediate access to such rescue apparatus as respiratory equipment and a lifeline 10 ft longer than twice the depth of the manhole and strong enough to support the weight of two men.

Section 7—Building Operation and Maintenance

Window Cleaning

Window cleaning, a hazardous occupation, can be made safe only by following these safety rules:

1. Inspect the safety harness each day before use. Make sure that all metal parts, ropes, and straps are in good condition.

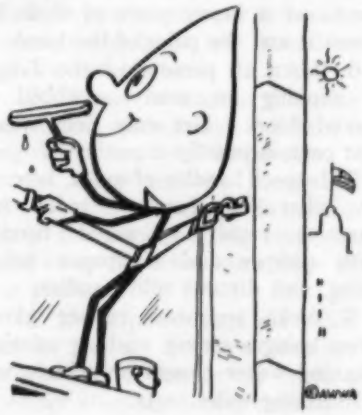
2. Examine window anchors before using them. If an anchor is loose or badly worn, do not use it but report it to the supervisor immediately.

3. If acid or alkaline cleaning solutions are used, inspect the safety rope frequently for chemical deterioration, and wear rubber gloves.

4. Before climbing outside, put one belt terminal in place on the anchor, and have both terminals anchored, without twists, before starting work.

5. If cold weather causes fingers to become numb, or if a high wind is blowing, immediately report the facts to the supervisor.

6. If work going on above creates a hazard from falling objects, inform the supervisor.



7. Always keep one belt terminal anchored until inside the sill.

8. Move from one window to the next only when inside the building.

9. Work with one hand only, and stabilize with the other, in order to place less strain on the safety belt.

10. Use one tool at a time, with a firm grip, to avoid dropping. Do not allow water to fall on pedestrians or vehicles.

11. Have the safety belt inspected by the supervisor at least once every 3 months.

Cleaning, Scrubbing, and Waxing Floors

1. Use only the proper containers for soap, powders, and other cleaning materials.

2. When scrubbing old or splintered woodwork or flooring, use only long-handled scrub brushes or mops.

3. Use wringers to prevent hand injuries from pins, pieces of glass, or other sharp objects which may be picked up by the mop.

4. Remove exposed nails, tacks, or splinters from the surface of woodwork before scraping or cleaning.

5. When using steel wool, wear gloves or a heavy piece of cloth between it and the palm of the hand.

6. Warn all persons of the danger of slipping on newly scrubbed or waxed floors. Use only floor waxes that contain nonslip ingredients.

7. Inspect handles of mops, brooms, or other long-handled tools frequently; repair splintered handles with scraper and sandpaper before using, and discard split handles.

8. Wear approved rubber gloves when using a strong washing solution, cleaning water closets or urinals, and disinfecting toilet seats.

9. Keep mops, brushes, pails, or other utensils out of hallways, doorways, or stairways, unless the equipment is in use at those immediate points.

10. Before dusting tops of lockers, tall cabinets, or similar items of furniture, look for, and remove, loose objects.

11. When working at a door, secure it, either open or closed.

Painting With Brush

1. When painting indoors or in closed areas, care should be taken to provide sufficient ventilation. When this step is not practical, suitable respirators should be used.

2. When working with lead, zinc, or other toxic-base paint, the hands should be kept away from the mouth and washed before handling food or tobacco.

3. The excessive use of solvents to remove paint from the skin should be avoided. Avoid using carbon tetrachloride. Protective creams are helpful in reducing the skin contact with paint or solvent.

4. Smoking or the presence of an open flame should not be permitted when there is a hazard of fire or explosion from solvent or paint vapors.

5. Rags containing oils or paints should be promptly placed in closed metal containers to reduce the hazard of fire.

6. The furnishing, construction, and use of ladders or scaffolds should conform to either existing safety regulations or ASA safety recommendations (see Sec. 1).

Spray Painting

1. An approved respirator should be used to reduce the hazard of inhal-

ing fumes or mists. When purchasing a respirator, be certain to obtain the correct apparatus for protection against specific substances.

2. Personal protective measures should be used to reduce unnecessary contact of excessive paint material or solvent with the skin.

3. Because fire is extremely dangerous, every effort should be made to reduce that hazard. No smoking or open flame should be permitted in the immediate area of the paint operation.

4. Explosion-proof lights should be the only source of illumination within the spray booth.

5. No electrical switch, outlet, or appliance capable of producing a spark should be permitted inside the booth, nor should an electrical connection for infrared drying be made or broken within the booth.

6. Compressed air should not be used for blowing down the interior of spray booths.

7. Falling water or a water spray immediately behind a paint spray operation in the booth often forms an excellent medium for the trapping and removal of excess paint, as well as a means of reducing the danger of fire or vapor explosion. The use of water should be in addition to the proper and adequate forced flow of air required to direct and convey the excess spray toward the water curtain.

Elevator Operation

1. Do not operate an elevator except with proper authorization.

2. Close and latch the gates or doors and make sure that people and objects are out of the way before starting the elevator.

3. Know the safe capacity of the car and keep within that limit.

4. Always be sure that the control is in a neutral position and the elevator is at a complete stop before the doors or gates are opened.

5. Require all passengers to face the front of the car. If scuffling or horseplay starts, stop the car and ask the participants to stop.

6. No material not a part of the elevator equipment should be permitted on the top or cover of any elevator car.

7. Never reverse the motion of an elevator without bringing it to a full stop, because to do otherwise puts a dangerous strain on the mechanism.

8. Take an elevator out of service if it does not work properly; report the defect immediately.

9. Make a trial inspection trip each morning before permitting passengers to be carried.

10. Do not carry passengers or freight while inspections, repairs, or adjustments are in progress. Do not move the car when anyone is in the pit or on top of the car, except as they may direct.

11. Ascertain that the locking device and safe-hoisting attachments are in place before a safe or other heavy, concentrated loads are moved on or off the car platform.

12. Do not attempt to raise the car more than a few inches until the locking device has been withdrawn.

13. Keep the car gates, if any, closed while the car is in motion; if gates are not provided, keep passengers away from the open edge of the car platform.

14. If the power goes off while the car is moving, set the control at the stop position; start the car in the usual manner after the power returns.

Section 8—Fire Protection

1. A neat, well ordered plant represents good safety policy. All crates, cartons, packing materials, paper, and other debris should be disposed of promptly. Suitable containers should be conveniently available for discarded, soiled wiping cloths. The personnel on duty should be responsible for elimination of obvious fire hazards.

2. An analysis of the various plant areas should be made to determine what possible types of fires could result. Fire extinguishers of the appropriate size and type (see Tables 10 and 11) should be chosen on the basis of such analysis.

3. Extinguishers should be located conspicuously in hallways and near

TABLE 10—*Typical*

Item	Type of			
	Soda and Acid	Water Type	Loaded Stream	Antifreeze
Suitable for Class A fires (wood, textiles, paper, rubbish, etc.)	yes	yes	yes	yes
Class B fires (gasoline, oils, grease, paint, alcohols, acetone, ketones, ethers, and "polar" solvents)	no	no	yes	no
Class C fires (electrical equipment)	not†	not†	not†	not†
Method of operating	invert	invert and bump on floor	invert and bump on floor	invert and bump on floor
Means of expelling extinguishing agent	chemical reaction to form carbon dioxide	carbon dioxide cartridge	carbon dioxide cartridge	carbon dioxide cartridge or chemical reaction
Effective range	30–40 ft	30–40 ft	30–40 ft	30–40 ft
Approximate duration of discharge at room temperature	2.5 gal, 1 min 1.5 gal, 1 min	2.5 gal, 1 min	2.5 gal, 1 min 1.75 gal, ½ min	2.5 gal, 1 min
Principal extinguishing effect	quenching	quenching	quenching or smothering	quenching
Protection from freezing required	yes	yes	no	no
Annual maintenance required	discharge, refill, and tag	weigh cartridge, renew water, and tag	weigh cartridge, restore liquid level, and tag	weigh cartridge, restore liquid level, and tag
Composition of extinguishing material	water with products of sodium bicarbonate solution and sulfuric acid reaction	water	water with dissolved potassium carbonate and special salts	water with dissolved calcium chloride†† and corrosion inhibitor
Weight fully charged	1.25 gal, 20 lb 1.5 gal, 25 lb 2.5 gal, 30 lb	2.5 gal, 35 lb	1.75 gal, 25 lb 2.5 gal, 40 lb	2.5 gal, 40 lb

* Prepared by Factory Insurance Assn, Hartford, Conn.

† This type of extinguisher can be used safely on fires in electrical equipment *only after* electric current has been shut off.

†† See Table 11 for data on calcium chloride solutions.

the doorways of workrooms. If several extinguishers are needed in a particular workroom, they should be freely accessible from all parts of the room. Lights, signs, and arrows should be used to indicate the location of extinguishers.

4. Fire extinguishers should be inspected at least semiannually, preferably quarterly. Tags should be affixed, giving the date of inspection and the name of the person who made it.

5. Extinguishers should be recharged after every use.

6. The fire prevention service of the local fire department should be consulted for advice on choice of equipment and its use. The fire department will usually cooperate fully in any fire prevention program.

7. The telephone numbers of the fire department and police department

*Available Fire Extinguishers**

Extinguisher					
Pump Tank	Water Pail§	Vaporizing Liquid‖	Foam	Carbon Dioxide	Dry Chemical
yes	yes	no, except very small fires	yes	no, except very small fires	no, except very small fires#
no	no	yes	yes	yes	yes
no†	no†	yes	no	yes	yes
pump	throw	pump or open valve	invert	open valve or squeeze trigger	open valve and nozzle
hand pump	throw	hand pump or stored pressure	chemical reaction to form carbon dioxide	under pressure in extinguisher	carbon dioxide cartridge
30–40 ft	5–10 ft	20–30 ft	30–40 ft	3–8 ft	5–20 ft
5 gal, 2 min 2½ gal, 1 min	variable	¾–1 min	5.0 gal, 1 min 2.5 gal, 1 min 1.5 gal, ¾ min	½–¼ min	½–¼ min
quenching	quenching	smothering	blanketing	smothering	smothering
yes, unless calcium chloride solution is used	yes, unless calcium chloride solution is used	no	yes	no	no
inspect, partly discharge, refill, and tag	empty and refill	inspect, partly discharge, refill, and tag	discharge, refill, and tag	weigh and tag	weigh cartridge and tag
water with or without calcium chloride††	water with or without calcium chloride††	carbon tetrachloride specially treated with corrosion inhibitor and freezing-depressant	foam from reaction of aluminum sulfate and sodium bicarbonate solutions with foam stabilizer	carbon dioxide as gas and snow	dry chemical
2.5 gal, 40 lb 5.0 gal, 65 lb	25–30 lb	0.25 gal, 7 lb 1.0 gal, 25–35 lb 3.0 gal, 75 lb	1.5 gal, 25 lb 2.5 gal, 35 lb 5.0 gal, 70 lb	7.5 lb, 35 lb 15.0 lb, 50–60 lb 20.0 lb, 55–75 lb	12–40 lb 20–55 lb

§ With or without cask or drum.

‖ These extinguishers should not be used near equipment which may be affected by the resulting highly corrosive vapors. Special precautions *must be taken* to avoid breathing the toxic vapors, particularly in confined or unventilated spaces.

Effective for initial attack on fires in combustible fibers, but requires a followup with fine water spray.

should be posted in a conspicuous location at every telephone location for quick reference in an emergency.

8. Several means of exit should be provided so that personnel will not get trapped in case of fire.

9. All exits should be distinctly marked and lighted at night. All doors should open outward and in hazardous locations should be provided with "panic bars."

10. Flammable materials should be stored in isolated structures if possible. If circumstances compel storage of such items in the plant, they should be kept in fireproof rooms equipped with fire doors, alarms, and automatic extinguishers. The latter devices should be supplemented by other equipment which can be operated from outside the fire door.

11. In the larger plants, alarms from the various installations should be brought into a central panel located at a point where a man is on duty at all times.

12. Explosion-proof lights should be used in flammable-storage areas, and, if indicated, the floor should be grounded and only spark-proof tools used.

13. Welding and smoking should be prohibited in flammable-storage areas.

14. Flammable-storage areas should be marked with distinctive signs; those at all entrances should be lighted during the night.

15. All employees should be instructed in the proper use of the different types of fire extinguishers available and in the general rules of fire fighting. The local fire department will usually assist in such a program.

16. All employees should have first-aid instruction. The absolute minimum of knowledge should include artificial respiration, treatment for shock, and the control of severe bleeding. The local chapter of the American Red Cross will give such instructions.

TABLE 11

*Calcium Chloride Solutions**

Freezing Temperature °F	Water gal	Calcium Chloride lb	Specific Gravity	Degrees Baumé
10	2.25	5	1.139	17.7
0	2.13	6¼	1.175	21.6
−10	2.00	7⅜	1.205	24.7
−20	2.00	8¾	1.228	26.9
−30	2.00	9⅞	1.246	28.6
−40	2.00	10⅞	1.263	30.2

* Calcium chloride furnished by extinguisher manufacturers contain a corrosion inhibitor.

Section 9—Trench Construction

Hand Digging

1. Wear protective hats when working in a trench.

2. Use only tools that are sharp and in good condition.

3. Keep a safe distance from other workers to avoid danger of striking them with tools.

4. Do not jump into a trench, but sit on the shoulder and slide in, if the trench is shallow. Use ladders where required. Before climbing out of a trench, look all ways for traffic danger.

5. Trenches 5 ft or more in depth should be supplied with a ladder for each 200 ft, or fraction, of open trench. The ladder should extend from the bottom of the trench to at least 2 ft above the top.

6. Be careful to remove earth and other material in such a way that overhanging banks are avoided. If undercutting is necessary, adequate bracing should be provided. The public should be restricted from all braced areas.

7. Where practical, do not place excavated material nearer than 2 ft from the edge of a trench. Otherwise, proper bracing should be provided if, in the opinion of the supervisor, it is necessary. Keep all tools, working material, and loose objects orderly and away from the shoulder of the trench.

8. Keep tools, equipment, and excavated material out of open traffic lanes. Pebbles and small stones should either be continually removed from, or prevented from lodging on a hard-surface roadway where tires may pick up and throw them, causing injury or damage.

9. If possible, keep the spoil bank between workmen and the traffic.

10. Provide and maintain all necessary barriers, temporary bridges and walks, warning signs, flags, flares, lights, and, when necessary, watchmen and flagmen for the protection of workmen, vehicles, and pedestrians (see Fig. 10).

11. Take all necessary measures to prevent accidents to personnel and damage to equipment (see the precautions listed under "shoring").

12. Do not go under an overhanging bank; when working near one, be very cautious.

13. If it is necessary to remove an overhanging bank, work from one side toward the center, always facing the point of danger.

14. If the walls of a trench contain glass, wire, or other sharp objects, carefully remove them at once.

15. When resuming excavation after heavy rains or freezing weather, inspect all banks for cracks, which may indicate earth movement and the probability of cave-in.

16. Require the person in charge to make frequent inspection of the sides and rim of all open trenches to guard against cave-in. Earth-moving equipment should be operated from a position that will not imperil personnel or property by a cave-in due to vibration, stress, or dead weight.

17. When making tunneled openings, be certain that the soil either is compact enough to prevent cave-in, or is suitably braced.

18. If it is absolutely necessary to work above an overhanging bank, use a safety belt and a lifeline, with a strong helper nearby to assist in an emergency.

19. If caught in a landslide, jump or run up the bank, never down.

20. Exercise every precaution to avoid striking electric or telephone conduits, gas lines, or other substructures, particularly when using a pick, sharpshooter, or air gun. Make every effort to locate other utility installations before starting work.

21. Require workmen to wear adequate eye and foot protection when using a jackhammer or when exposed to flying particles or falling objects. Protect passers-by and property with canvas screens around impact work.

22. Always face such machinery as a clam shell, backhoe, or trenching machine, and stay beyond one shovel length from the sweep of buckets or extended booms (see Fig. 11).

23. Hold impact tools to be struck or sledged by another workman by tongs or toolholder, and not by hand.

Trenching Machines

1. Never attempt to oil or grease the mechanism or to repair or adjust any moving part of a trenching machine while it is in use; only qualified personnel should operate it.

2. Guard all moving parts. Make sure, before starting the conveyor, that no person is endangered by it.

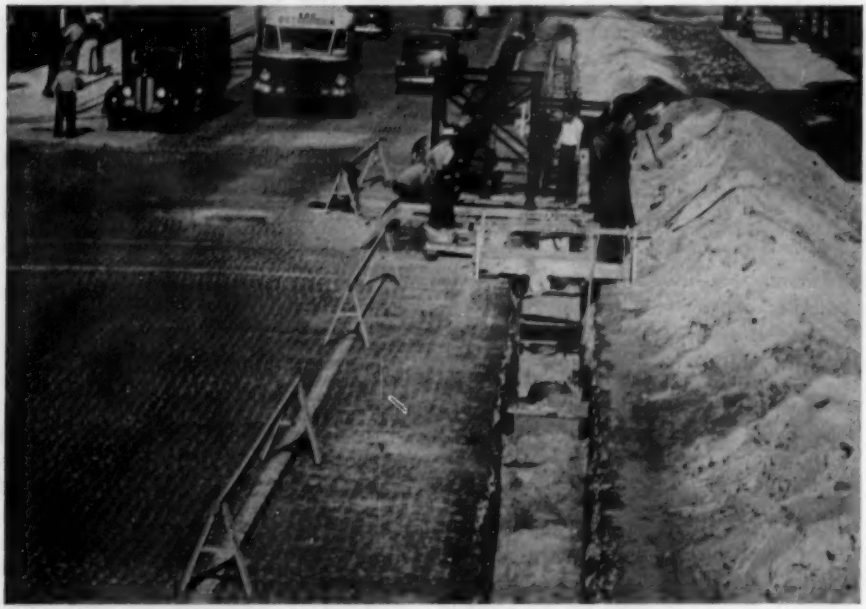


Fig. 10. Installation of 24-in. Main on Busy Street

The pipe is used as a barricade prior to its installation. The shoulders at both sides of the trench are clear and usable by workmen.

3. To remove obstructions from the conveyor mechanism or buckets, stop the machine.

4. Be alert for falling materials that might roll from the conveyor.

5. When practicable, drop trench dirt between the trench and the highway to act as a barrier.

6. Fill gasoline tanks with utmost precaution. Keep spout in metallic contact with the machine to prevent static sparks from bridging the gap and igniting the fumes; do not smoke.

7. Use flags by day and flares by night to warn the public of the presence of the trenching machine and its operations. These precautions should be liberally taken on all highway or street work.

8. Operate the machine in a true vertical position to prevent undercutting the trench walls.

9. When loading or unloading trenching machines or other heavy equipment from truck beds, lowboys, or other conveyances, provide suitable skids and ample blocking to guard against accidents.

10. Take care not to become drowzy while operating a trenching machine.

Shoring

Proper trench shoring cannot be reduced to a standard formula. Each job is an individual problem and must be considered under its own conditions. The ASA lists specific recommendations for shoring of trenches.* The following are general precautions:

1. Do not take chances that may lead to injury or work stoppage.

2. Either use tight sheet shoring to guard against the caving in of sandy soil or loose material when the depth of the trench exceeds 4 ft, or cut back the bank to a safe angle of repose. Keep shoring at or near the bottom of the ditch as it is excavated, and follow with bracing.

3. Use closely placed plank shoring to guard against cave-in by a soil that is saturated with water, subject to vibration, in a refill area, or over 6 ft deep.

Fig. 11. Trenching Machine

The workers near the machine are facing toward it as a safety precaution. Men wearing hard hats in a ditch receive protection against falling objects.

4. In hard clay, rock, or stable soil, use vertical planking, braced at intervals against the walls to shore trenches.

5. Extend shoring of any type below the bottom of the trench whenever

* Safety Code for Building Construction—ASA A10.2–1944, Am. Standards Assn., New York.

possible and brace it thoroughly either with screw jacks or by timbers placed at right angles to the shoring and rigidly cleated and screwed or wedged in place (see Fig. 12 and 13).

6. Use only full-sized lumber that is sound and straight.

7. Install the upper braces or screw jacks first and remove them last for best protection.

8. Be aware that trench dimensions, soil stability, variable weather and moisture conditions, proximity of other structures, weight and placement of spoil and equipment used on the job, and sources of vibration are other important factors in choosing the type of shoring to use, if any. The decision must rest with the engineer or foreman.

Fig. 12. Trench Bracing

The screw jack should always be installed first, from the top of the trench. The jack should never be placed from within the excavation.

Section 10—Blasting Operations

A novice should not handle, store, or otherwise work with explosives. Only experienced men should be permitted to do so. These principles for avoiding accidents in the use of explosives must be heeded:

1. Have the fewest possible men handle explosives, because that precaution will reduce the risk of accident.

2. Choose the men who handle explosives for intelligence and good judgment, and train them properly.

3. Rigidly enforce all safety regulations.

4. Avoid the use of a short-wave radio near blasting areas, as it might prematurely detonate a charge.

5. Use the training and skill of the explosive manufacturer's technical representatives to instruct the field crews in all blasting practices.

Storage of Explosives

1. Avoid purchase, possession, storage, transportation, handling, or use of explosives except in accordance with local, state, and federal regulations.
2. Store explosives only in a magazine that is dry, well ventilated, properly located, substantially constructed, and securely locked.
3. Do not leave explosives where children can get them.
4. Keep the area clean and clear within 25 ft of a magazine.
5. Do not permit smoking, carrying of matches, open lights, or other fire or flame in or near a magazine or while explosives are being handled.
6. Prohibit the use of firearms in the vicinity of a magazine.
7. Store only explosives in a magazine, leaving all other materials outside.
8. Replace the cover on a partially used package or case of explosives.
9. Store all cases of dynamite so that the cartridges lie horizontally.
10. Store blasting caps or electric blasting caps in a box, container, or magazine separate from other explosives.
11. Protect blasting caps or electric blasting caps from the direct rays of the sun.
12. Store fuse or fuse lighters in a cool, dry place, well away from any flammable liquids.

Handling of Explosives

1. Handle explosives carefully and with respect.
2. Open kegs or cases of explosives only outside and away from the magazine.
3. Use wooden, rubber, or fiber tools for opening cases of explosives.
4. Burn empty explosives cases in the open to prevent them from being used as fuel by someone.
5. Keep explosives out of clothing pockets.
6. Prevent sparks from construction machinery or welding operations from falling in or near explosives or drilled holes being loaded with explosives.
7. Permit only essential persons near the blasting area.

Fig. 13. Braced Trench

This excavation has been carefully braced and shored to prevent accidents.

8. Destroy all explosives in strict accordance with the methods recommended by the manufacturer.
9. Keep surplus quantities of explosives out of the tunnel or shaft during blasting operations.
10. Remove blasting caps from the box with fingers only. Keep wire, nails, or other instruments out of the open end of blasting caps.
11. Do not tamper with or remove the wires of an electric blasting cap.

12. Do not tamper with or change the circuit of a blasting machine in any way, or for any purpose.

13. In cold weather, warm the fuse slightly before uncoiling to avoid cracking the waterproof coating.

Use of Explosives

1. Avoid using explosives that have become obviously deteriorated by water or from age.

2. Do not make up primers in a magazine or near explosives.

3. Do not force cartridges of any explosives into a bore hole or past any obstruction in one.

4. Avoid springing a bore hole near another one loaded with explosives.

5. Be sure the hole has cooled sufficiently before springing a second time.

6. Use only a wooden stick for tamping.

7. Use only noncombustible material for stemming.

8. Be certain that all surplus explosives are in a safe place, all persons and equipment are at a safe distance or under sufficient cover, and adequate warning has been given before firing a charge.

9. Be sure smoke and fumes have been dissipated before returning to the blast area.

10. Recharge a misfired explosive with a new detonator and make another attempt to set it off; do not drill, bore, or attempt to pick out the explosive.

11. Use only one manufacturer's blasting caps in a circuit.

12. Discontinue all blasting operations during electrical storms. Be careful during a high wind, as it may produce sufficient static to detonate charges.

13. Use a blasting galvanometer to test all electric blasting caps before using and when connected in a circuit.

14. Use No. 14 gage single conductor copper blasting wire; be certain that the wire ends are bright and clean before making electrical connections.

15. Cap leg wires should not be cut unless absolutely necessary.

16. Insulate or isolate blasting circuits from all possible sources of current or paths of leakage.

17. Eliminate all electric wire or cable from the blasting area, except that required to set off the charge.

18. Use waterproof electric blasting caps and lead wires when blasting in wet conditions.

19. Be sure to operate a blasting machine with maximum force.

20. Cut the fuse only when ready to insert it into a blasting cap; with clean, sharp blade, squarely cut off inch or two of the fuse to insure a dry end. Without twisting, seat the fuse lightly against the cap charge.

21. Cut the fuse long enough to extend at least 2 ft beyond the collar of the hole to allow time to get safely away. The minimum length of a safety fuse is 36 in.

22. Use a standard cap crimper, making sure that the cap is securely fastened to the fuse.

23. Under wet conditions, thoroughly waterproof the joint between fuse and cap.

24. Keep the fuse free of kinks at all times.

25. Use sufficient stemming to protect explosives from the end spit of a fuse or flying match heads.

26. After a blast has been made, only an experienced powderman should be permitted to work in area until it is definitely proved safe.

27. Use delay electric caps for setting off charges in footing holes.

Palate-inviting water
may not have the same aroma and
effects as wine, but it is still a delight to drink.

People appreciate and are demanding fine tasting sparkling water. As a means of giving water proper treatment to minimize complaints, water plant operators have come to rely upon AQUA NUCHAR activated carbon. It offers effective and economical means of crossing the threshold into palatable and sparkling water.

Without any obligation Industrial Chemical Sales will send their Threshold Odor Specialists to conduct a complete taste and odor survey in your plant. They will explain the procedures of the Threshold Odor Test and advise how to use AQUA NUCHAR-activated carbon with other water-treatment chemicals. In addition, they will also aid in determining the most economical and effective point of application for AQUA NUCHAR. To take advantage of this service call your nearest Industrial office.

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TRIDENT

"BALANCED DESIGN"

MEANS

QUIET, DEPENDABLE OPERATION

Three problems that give meter superintendents gray hairs . . . noisy meters, broken discs and premature failures . . . have as their primary causes turbulence, interference, and improper motion of the disc piston. Here's how Trident meter's "balanced design" eliminates these faults:

The Trident disc is axially controlled. The thrust roller . . . a Neptune "first" . . . guides the disc in the exact path necessary for smooth, balanced flow of the water. No sloppy or eccentric motion to cause noise, disc breakage or excessive wear. Inlet and outlet ports, and the casing itself are carefully designed for smooth, uninterrupted flow of water. There is no turbulence caused by water circulation up through the gear train and stuffing box . . . these are permanently lubricated and sealed from the path of the water.

We believe the Trident meter, if properly installed, is the quietest, most dependable meter you can buy. It's one of the many reasons why more Trident meters have been bought in the past 50 years than any other meter.

NEPTUNE METER COMPANY
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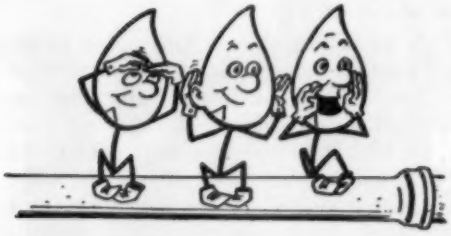


Percolation and Runoff

Dearth cheap is what the long sought support of the public may turn out to be—dearth at home primarily, direct and uncomfortable, but elsewhere, too, as the nation's newspapers and magazines continue to lavish billions of dollars' worth of publicity on the waterlessness of almost everywhere. As more and more people run into dearth wherever they turn—in their work, in their play, in their homes and gardens—and as more and more people read about dearth wherever they turn—in *Time*, in *Pageant*, in *Argosy*, in the *Wall Street Journal*, even in *True Romances*—they're bound sooner or later to become conscious that water is something more than a mere plumbing exudation. Even so, this dearth-promoted attention, understanding, and concern is only half the battle. Unless action follows, the dearth will be anything but cheap.

If action does follow, of course, it, too, is bound to be anything but cheap, involving such facilities as dams, underground recharge systems, and bigger and better pipelines to redistribute presently available water in either time or place, or, even more expensive, programs for increasing the amount of water available for our use. Potentially important as are such means of increasing the actual raw material on hand as sea water conversion, cloud seeding, and the destruction of the water-wasting phreatophytes, water works must, generally, stick to the more financeable facilities for redistribution of existing material. Even so, if present public attention and concern grow into public support, the end of present dearth is in prospect, for there always has been enough water available—only not enough funds to insure its proper distribution.

In the East's growing concern over water rights and in the increasing interest in metropolitan and regional schemes for water supply these days, many sense an awakening of public appreciation of the importance of water supply to the economy as a whole, as well as to the individual. It has been the absence of such appreciation, of course, that has been the basic obstruction to equating the price of water supply with its worth and, thus, to permitting water utilities to equate their systems to the future needs of their communities. Even after such an equation the public could be assured that water would remain a good bit cheaper than dirt and infinitely cheaper than dearth!

A real measure of public appreciation of water supply, incidentally,

(Continued on page 36 P&R)

(Continued from page 35 P&R)

was a bill which the Assembly of the New Jersey Legislature passed by a 34–5 vote last May to reactivate the charter of a water company that had been "declared inoperative and void by proclamation of the governor for nonpayment of taxes." What prompts us to consider it significant is not so much the size of the vote as the fact that the bill was passed despite the inability of the assemblyman who introduced the bill or the committee who reported it out to identify the water company involved. "Just Plain Bill" was the title the Newark *Evening News* gave the measure—a measure of the quantity, if not the quality, of appreciation that water workers want.

George A. Baer has been named application engineer in the Valve Sales Div. of S. Morgan Smith Co., York, Pa. Mr. Baer, who joined the firm in 1947, has worked in both the turbine and the valve design departments.

J. R. Hoover, president of B. F. Goodrich Chemical Co., Cleveland, has been elected chairman of the board of the Manufacturing Chemists' Assn., succeeding Fred J. Emmerich, president of Allied Chemical & Dye Corp., who continues as a director of the association. William C. Foster was re-elected MCA president.

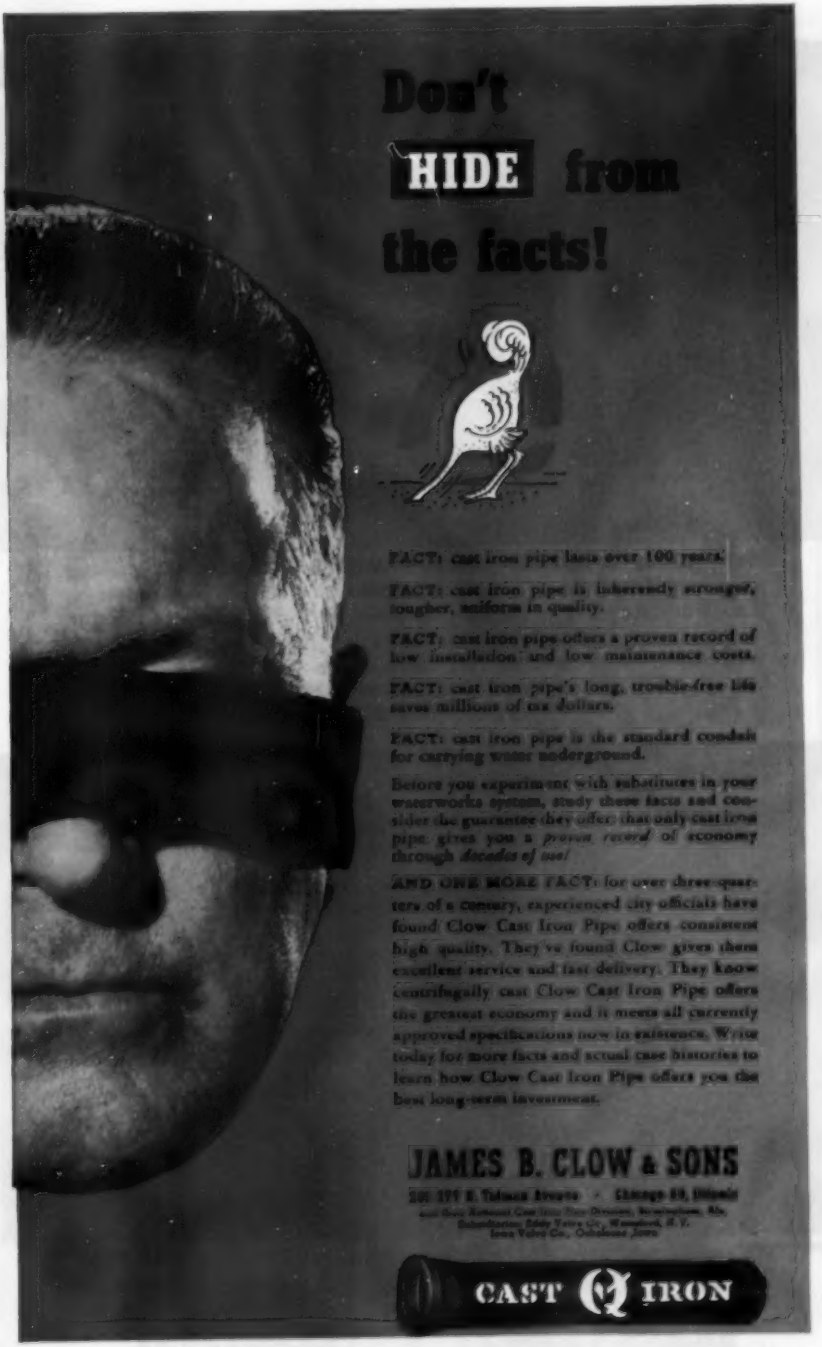
Worthington Corp., Harrison, N.J., announces the appointment of Hellmuth Walter as director of research and Robert S. Sherwood as assistant director. Before joining Worthington, Mr. Walter worked with the German and British armed forces on the development of hydrogen peroxide as a propellant, while Mr. Roberts was professor of mechanical engineering at Iowa State College.

In Cuba, AWWA news is front-page news, and in murder-size type yet! Thus, when our Cuban Section held its meeting in Havana last Jun. 9–10, the two leading dailies—*El Mundo* and *Diario de la Marina*—gave it king-size spreads on their front pages, *El Mundo* running a four-column picture of the speakers' table at the opening of the meeting by Section Chairman Ernesto E. Trelles, as well as a picture of former Section Director Jose Garcia-Montes presenting one of the papers. Only trouble with the half-page or more of detailed coverage in each paper was the fact that it was in Spanish, which means that we'll have to wait for Secretary Larry Daniel's translation of it all before we can give you the scoop. Knowing just about enough of the language to appreciate how often the name of the Association and the names of its members appeared throughout, we're already ready to hold the publicity up as a model not only for other section meetings but for the annual conference as well. Only, whatever the language, we do wish people wouldn't stop after that third letter in abbreviating "Association."

Chi high included not only more people than ever before, but more lucky people, for, beginning with the ladies' card party on Monday afternoon, every day produced a host of prizewinners. With winners at every one of a hundred tables, Monday's card sharks were a little too numerous to mention, but for the days that followed the records were a little more complete:

Tuesday's golf tournament at the Medinah Country Club rewarded 19 of the 96 who participated, with the first-prize silver bowl going—and not for

(Continued on page 38 P&R)


Don't
HIDE from
the facts!
FACT: cast iron pipe lasts over 100 years.
FACT: cast iron pipe is inherently stronger, tougher, uniform in quality.
FACT: cast iron pipe offers a proven record of low installation and low maintenance costs.
FACT: cast iron pipe's long, trouble-free life saves millions of tax dollars.
FACT: cast iron pipe is the standard conduit for carrying water underground.
Before you experiment with substitutes in your waterworks system, study these facts and consider the guarantee they offer: that only cast iron pipe gives you a proven record of economy through decades of use!
AND ONE MORE FACT: for over three-quarters of a century, experienced city officials have found Clow Cast Iron Pipe offers consistent high quality. They've found Clow gives them excellent service and fast delivery. They know centrifugally cast Clow Cast Iron Pipe offers the greatest economy and it meets all currently approved specifications now in existence. Write today for more facts and actual case histories to learn how Clow Cast Iron Pipe offers you the best long-term investment.
JAMES B. CLOW & SONS
CAST IRON

(Continued from page 36 P&R)

Welcomed to Chicago last June for AWWA's 75th Annual Conference were AWWA Secretary Harry E. Jordan (on the left) and (next to him) Undersecretary of Interior Clarence A. Davis, whose address on national water resources policy will appear in the September issue. Welcomers were (next to Mr. Davis) Mayor Richard J. Daley of Chicago and (on the right) Commissioner James W. Jardine of the Dept. of Water & Sewers.

Welcomed, too, were AWWA's bosses' bosses: Mrs. Veep Paul Weir (center) and Mrs. Prexy Frank Amsbary; their welcomer, actor Russell Nype, male lead in "The Tender Trap" and, formerly, in "Call Me Madam." Occasion of the welcome was the ladies' tea and fashion show, at which Nype was guest of honor and awarder of the door prizes.

(Continued on page 40 P&R)

How to Locate Water Leaks

WITH SIMPLEX PITOT EQUIPMENT

WHY not decrease your load and stop pumping to waste? Locate the hidden leaks which waste thousands of gallons per day per mile of main . . . far more than usually guess-timated!

Locating these leaks with Simplex Pitot Equipment costs only a tiny fraction of the value of the water being wasted. You get accurate flow records with minimum effort . . . valuable data that will help you to reduce "unaccounted-for water" to a minimum.

PITOT ROD

Simple, rugged and lightweight. Easily installed on any pipe or main. Special clamp holds tube firmly in position against water pressure.

Low coefficient gives high differential pressure for greatest accuracy.

MANOMETER

Quickly connects to a Simplex Pitot Rod with flexible tubing. You then have a simple, sensitive and inexpensive instrument for indicating rate of flow.

Can be used for wide flow ranges . . . low or high.

PITOT RECORDER

Connects easily to Pitot Rod. Eight-inch chart records flow data. Simple and rugged construction . . . no delicate mechanisms . . . yet sensitive and accurate.

Sturdy carrying case. Leveling feet. Reliable 7-day clock movement for chart. Accurately calibrated.

Get the Facts!

Free 20-page Technical Bulletin 1300. Full instructions for use and care of Pitot equipment. Seven pages of helpful formulae, tables, curves. Write to Simplex Valve & Meter Co., Dept. JA-8, 7 E. Orange St., Lancaster, Pa.

SIMPLEX®

VALVE AND METER COMPANY

(*Continued from page 38 P&R*)

the first time by a long putt—to Mel Hatcher, director of the Kansas City, Mo., water department, whose 91 was low gross among the operators. Premier peddler was Al Scheinert of Rensselaer Valve Co., whose 82 won him a silver tray. And first and second low netters were also members of the unworried and unharassed class, Charlie Comstock of Dorr-Oliver Inc. and Mack Albertson of Lock Joint Pipe Co., each receiving a golf bag. Among the ladies, Mrs. H. Kermit Green, wife of one of the commissioners of the North Jersey Dist. Water Supply Commission finished on top, with first low net going to Mrs. Ira Collar of the Neptune Meter Co. distaff. Each won a golf jacket. And unchallenged champion husband and wife combination were Mr. & Mrs. Harry Wooster of the Consumers Water Co., Portland, Me., who were eleventh low net and second low gross, respectively, and who took home a locker robe and a golf jacket for their prowess.

Tuesday night's Diamond Jim Carnival also had prizes for practically everybody—to buy with bogus bucks if not to win at gambling—but the hottest competition was for the Gayest Ninetieth Costume Award. There, two couples walked away with all the loot: Mr. & Mrs. "Brockie" Brock of Joseph H. Pollard Co. for the best costumed couple and Mr. & Mrs. Harry E. Schlenz of Pacific Flush Tank Co., individually, for the best male and best female getups. The Brocks won a silver bowl and the Schlenzes a gold wristwatch and a gold necklace.

Wednesday's Fashion Show & Tea at Marshall Field's gave all the ladies souvenirs and then awarded as door prizes the costume worn by the prize model of the show. Better yet, Russell Nype, male lead in *The Tender Trap* and, formerly, in *Call Me Madam*, was on hand to pass out the prizes: the first-prize suit to Mrs. William J. Downer, wife of the assistant chief sanitary engineer of the Illinois State Dept. of Public Health; the second-prize hat and purse to Mrs. Edward T. Davis, whose husband is partner in The Chester Engineers of Pittsburgh; and the third-prize umbrella to Miss Mary Elizabeth Hansen, daughter of the superintendent of purification and pumping at Mt. Clemens, Mich.

Finally, on Thursday, as registration closed at a total of 2,587, it was Frank Amsbary and Bill Brush who split the Directors' Pool of $70 for the closest guess of attendance. It is, of course, significant that their guess of 2,500 was topped by only three of the 70 made—those of Tip Allen (2,750), Mrs. Lew Finch (2,897), and Mrs. Dale Maffitt (3,035). It is, definitely, not significant that the winners were the rookie president and the veteran treasurer of AWWA; were it, it would have been their wives; or was it?

As a matter of fact, everyone who was at Chicago went away a winner, for there was more information, entertainment, and fellowship to be won there than at any other meeting ever. The Chi high, it is said, will be around for a good long time before it is outdone. Until next May, says Vic Weir, who will chairman next year's Diamond Anniversary meeting, then "St. Lou outdo."

B-I-F Industries announces an expansion of customer facilities. M. H. Strickland has been appointed manager of industrial sales for the Chicago Dist., which will now handle the complete industrial line for Proportioneers,

(*Continued on page 42 P&R*)

THE RIGHT TOOL SAVES TIME AND MONEY

LEARN ABOUT THESE SPRING LOAD MONEY-MAKERS!

Discover the time and money saving qualities of Spring Load Tools. See why thousands of plumbers and contractors, water and sewage department officials, public works department heads and others specify "Spring Load." There is a dealer near you . . . ask for a demonstration.

CAST IRON PIPE CUTTER

Cuts with equal pressure all around the pipe. No splits . . . no breaks . . . no spoilage. Even apprentices or helpers can cut pipe four to ten times faster than with old fashioned methods. Use for Cast Iron, Duriron, Vitreous Clay, Water Pipe and Cement Sewer Tile.

ASBESTOS-CEMENT PIPE CUTTER

You get easy, fast and clean cutting on any asbestos-cement pipe with this on-the-job tool. Practical in the field, at the shop and on the stock pile. Field proved, this tool reduces cutting time 50%. Light weight—easy to use—no pipe spoilage.

GRAVITY GRIP VISE

The 10 second set-up for cutting pipe on the job. Adjusts in seconds . . . holds short or long pieces, bends and fittings. Sturdy, compact, easy to transport, the Gravity Grip Vise is a "must" in the shop and on the job.

SPRING LOAD TENON TOOL

For asbestos-cement or wood pipe field tenons to a factory finish. Machines tenons any length up to 6'. A one-man tool—adjusts in seconds. Close-tolerance cuts eliminate adapters. Light, portable, on-the-job tool. No chatter—cuts are lathe-smooth.

All Spring Load Tools are unconditionally guaranteed against faulty workmanship or faulty materials.

Send for literature and prices.

SPRING LOAD

MANUFACTURING CORPORATION

3610 FIRST AVE. SO. • SEATTLE 4, WASH.

(Continued from page 40 P&R)

Inc. Two new offices, at Milwaukee and Indianapolis, will be headed by Harold D. Bugg and Byron Anderson, respectively.

A chain wrench with replaceable steel jaws has been placed on the market by Reed Mfg. Co., Erie, Pa. The new design is said to outperform conventional pipe wrenches in that it permits working in cramped quarters and makes it possible to tighten and back off a pipe or fitting without removing the wrench from it or changing the setting. The tool is available in 10–36-in. lengths.

Fairbanks, Morse & Co. has formally opened a regional sales and service headquarters at Fair Lawn, N.J., to facilitate prompt delivery and overnight emergency service throughout a seven-state area. Sales offices will continue to be maintained at Baltimore, Philadelphia, and New York.

Norman H. Abrams has been appointed Southwest Dist. sales manager for Badger Meter Mfg. Co. Mr. Abrams, a registered professional engineer residing at Waco, Tex., has been with the company since 1926.

Water and coffee in combination have long been the awakener of the world. And if the combination is much too often anything but perfect, quantitatively at least, water certainly cannot be blamed. Too much water? Never! Too little coffee? Almost always! Which is to point out that coffee brewing is one of the few necessities of life which have not yielded to the rule of "just add water." Even those undiscriminating millions who have had no more taste than to yield to the lure of the instantaneous concentrates cannot "just add water" without diluting their coffee-colored potion. Inasmuch as it is the water which is drunk, one must "just add coffee" and, as far as we've always been concerned, the more the better.

What brought this matter to a boil just now was the discovery of a means of applying the "just add water" principle to coffee, increasing the amount without diluting the beverage. The answer, of course, has been to apply the water long before the brewing stage. Thus, in a sample area in the state of Sao Paulo, Brazil, last year, irrigation was responsible for increasing the yield of coffee from 750 to 1,300 kilos per 1,000 trees. On that basis, it was estimated that the use of sprinkler irrigation on plantations of 60,000 trees, which account for half of the state's coffee production, would lead to a crop increase amounting to 3,700,000 bags.

Just keep adding coffee!

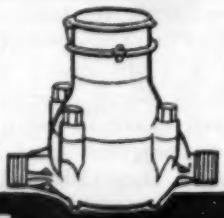
Fischer & Porter Co., Hatboro, Pa., has promoted four managers to vice-presidents in charge of their respective divisions. The men are: Robert A. Stern, Data Reduction & Automation Div.; Louis A. Aricson, International Div.; Nathaniel Brewer, research; and Edward J. Querner, manufacturing.

A new, heavy-duty, wheel type ditcher has been introduced by Gar Wood Industries, Wayne, Mich. The "Buckeye 308" digs to a maximum depth of 5½ ft, with optional width of cut (16–32-in. increments). Soil discharge conveyor damage is said to be eliminated by a hydraulic drive. The ditcher has sixteen forward digging speeds, the excavator wheel and traction speeds being entirely independent of each other.

(Continued on page 44 P&R)

MEASURES
the smallest amount...

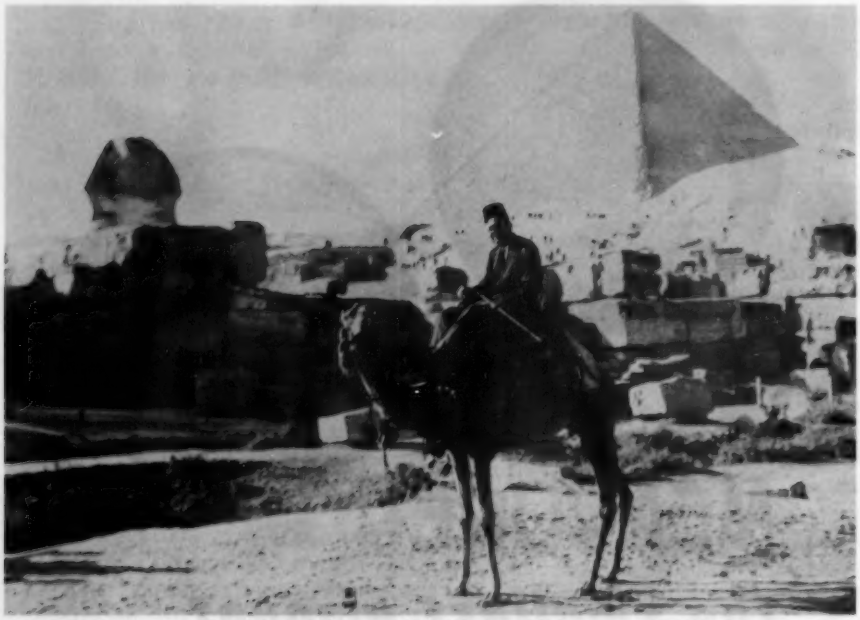
With Calmet you can forget about loss of revenue from faulty metering. Calmet measures and records accurately . . . from the smallest drop to the largest flow.



CALMET

MANUFACTURED BY WELL MACHINERY & SUPPLY CO., INC.
FORT WORTH, TEXAS

(Continued from page 42 P&R)



The fez is familiar in those surroundings if not the face; but for a Weir in the desert, go-wester Bill is doing fine.

It's a small water works world, too, a fact which must have been evident at the third International Water Supply Congress and Exhibition in London last month when at least five AWWA representatives fancied meeting each other there. Sherman Chase of Metcalf & Eddy Engrs. was on hand as official North American Reporter as well as one of the speakers on the five-day program. Fred Merryfield of Oregon State College dropped in from vacationing at his folks' home in Lancashire. Hubert O'Brien of A. P. Smith Mfg. Co. was there en route home from Geneva, where he was one of the US delegates to the UN's International Labor Organization conference. Sam Morris, head of the Los Angeles Dept. of Water & Power, stopped by on his way *to* Geneva, where he will attend the UN atomic energy meeting. And AWWA Secretary Harry Jordan was on hand to represent the Association.

Of course, all this was dropping in on the neighbors compared with some of the globe spanners that drop by these days on their way to or from places as distant as they are unpronounceable. Bill Weir, Director of Water Pollution Control at the Georgia Dept. of Public Health, made the complete circuit a few months ago, when he headed west on a three-month WHO advisory mission to the government of Nationalist China in Formosa. Mission completed, Bill continued west, took time off to talk to the Sphinx about Saharan water problems (see cut), and finally arrived at AWWA headquarters to give us travelitis. Not

(Continued on page 46 P&R)

MUELLER

Connect Branch Mains...

quickly
safely
simply

under pressure!

Mueller Tapping Sleeves and Valves are put in service under pressure with a Mueller "CC" or "C-1" Drilling Machine—no shutdown, no loss of water, no interruption of flow in main!

One mechanical joint sleeve of a nominal size will fit all classes of cast iron pipe regularly used by using only two sets of gaskets. Main sizes from 4″ through 12″ with various combinations of outlet sizes 2″ through 12″ are available.

Special mechanical joint tapping valve has oversize waterway—allows full-size cut for maximum flow. Exclusive four-point disc wedging mechanism assures tight shutoff. Available with "O" rings or conventional packing in sizes 2″ through 12″.

Calked type sleeves are available which will fit all classes of pipe for mains 3″ through 36″ with various outlets 2″ through 16″. Calked type valves are available with "O" ring or conventional packing or flanged type for post indicator with conventional packing only—sizes 2″ through 16″.

Consult your Mueller Representative, Catalog W-96 or write direct for full details.

MUELLER CO.

Dependable Since 1857

MAIN OFFICE & FACTORY DECATUR, ILLINOIS

(Continued from page 44 P&R)

long before there was Major Hagar of Sterling, Kan., headed the other way to Point 4 it in Iran, from which his monthly *Caspian Newsletter* now teases us with tales of inspecting the Shah's palaces, roaming the Persian gardens, eating chiloh kabab, and, generally, enjoying his work. And then, of course, there is the ever everywhere Jack Hinman, now someplace in Guatemala, Honduras, El Salvador, Panama, or Costa Rica, visiting water plants operated by students whom he taught in Guatemala. Due back home in Iowa in August, Jack will be looking for new water worlds to conquer.

Small worlding it, too, are other than American water workers, as ought to be evident from the Chicago Conference roster, which lists visitors from North Borneo, Korea, Egypt, Iran, and South Africa, as well as Chile, Bolivia, Venezuela, Canal Zone, Puerto Rico, and Hawaii. And then there is the constant stream of water plant visitors from Australia, Japan, Britain, and the Continent that keeps AWWA's engineer of protocol busy with sign language and schedule. As a matter of fact, things are getting to the point where we wouldn't be too surprised, one day, to have some one drop in on us from Brooklyn.

Henry S. Patterson II has been appointed executive vice-president of Elizabethtown Water Co. Consolidated, Elizabeth, N.J. Mr. Patterson has been secretary-treasurer of the company since 1950.

(Continued on page 48 P&R)

AA QUALITY

For Public Water Fluoridation

Sodium Silicofluoride—98%

(Dense Powder)

Sodium Fluoride—98%

(Dense Powder or Granular)

Meets AWWA specifications

White or tinted blue
Minimum of dust in handling
Minimum of storage space

Available in bags and drums

The AMERICAN AGRICULTURAL CHEMICAL Co.

50 Church Street, New York 7, N. Y.

OLD AGE SECURITY
WITH STRONG STEEL PIPE

Dependable service through the years is yours when you choose durable steel pipe for your water system. As evidence we could cite case after case where steel pipe lines have given 70, 80 or even 90 years of trouble-free use. And that is only the beginning of a long life story.

With today's technological improvements in steel pipe you can now count on even *longer* years of *more* dependable service.

In every way reliable service becomes an old, old story . . . when you use stronger steel pipe. Tough resilient steel—made to last—assures you a safe and secure pipe that will best serve your needs today—and for 100 years to come.

So if you want "old age security" in your water line, you're smart to specify STEEL pipe.

"WHEREVER WATER FLOWS—STEEL PIPES IT BEST"

STEEL PLATE FABRICATORS ASSOCIATION

79 W. MONROE ST., CHICAGO 3, ILL.

(Continued from page 46 P&R)

A $100 bill—water bill, that is—for regular residential service sounds almost as if someone finally put a proper price on our product, but no such luck! Actually, the Wallington, N.J., family that received the bill was getting its water at considerably less than even the going rate, for the bill covered water service for a full thirteen years, and the $100 was merely a settlement which had to take into account such factors as ability to pay, the statute of limitations, and, perhaps, even public relations.

What happened, according to the Borough Water Department, was that workers assigned to the job of installing a meter in the house, shortly after the distribution system was laid, apparently failed to do so. What happened, in the meantime, to the meter reader who was supposed to read the meter that wasn't there is not disclosed. Not a vicious dog, certainly, or there would have been at least a curbside reading. "No meter, no matter" it seems to have been, and now, perhaps, "no meter reader."

Meanwhile, there were no "no bill" complaints.

Charles M. Hickey, Sam S. Emison, and Jennings C. Crowder have been named vice-presidents of Consolidated Chemical Industries, Inc. Mr. Hickey will continue as manager of manufacturing, and Mr. Emison as sales manager, of the Southern Div., Houston, Tex. Mr. Crowder moves to San Francisco to assume the newly created position of general manager, New England and Pacific divisions.

(Continued on page 50 P&R)

BELL JOINT LEAK CLAMPS
GASKET SEALER COMPOUND
C-I-60 CAST IRON BOLTS

Carson glands and bolts made of corrosion-resistant C-I-60 cast iron—last as long as cast iron pipe. Glands accommodate variations in pipe dimensions, insure uniform compression of rubber gasket.

Write for information

H. Y. CARSON COMPANY
1221 Pinson St. Birmingham, Ala.

For Organic Iron and Color Removal—Algae Control—Regeneration of Iron Removal Filters—

Use

POTASSIUM PERMANGANATE

Supplied to industry and municipalities in various grades and meshes to fit the particular operation efficiently and economically in combating many water problems.

WRITE FOR QUOTATIONS

CARUS CHEMICAL COMPANY
Box JAW LaSalle, Illinois

Model GLW-0 Loss-in-Weight Gravimetric Feeder for maximum rate of 100 lbs. per hour.

Model GLW-1 Loss-in-Weight Gravimetric Feeder for maximum rate of 1,000 lbs. per hour.

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(Continued from page 48 P&R)

The Fountain of Youth is dry—not through drought either, or even the cynicism of modern man, but through action of the Pennsylvania Department of Health. The Steel City's Fountain of Youth this was, located in a park in the North Side section of Pittsburgh and shut down last month because the health department found its waters contaminated. Proof enough this, for some, that juvenile delinquency is waterborne.

Fountains of age, on the other hand, were those created in Lebanon, Pa., recently, when the city water bureau tested its new pumping station there. Not only three of the town's mains, but the plumbing of many houses burst with the higher pressures and spouted forth gushers of brown, iron-stained water. Arteriosclerosis must be the diagnosis, and in pipe, at least, that's waterborne too.

Wallace & Tiernan Inc., Belleville, N.J., anounce the appointment of J. C. Brigham as chief engineer. He is succeeded as manager of the Div. of Technical Services by L. E. Demler, formerly manager of the Chemical Feeder Dept.

George E. O'Brien, factory manager at the new Rockwell Mfg. Co. water meter plant at Uniontown, Pa., for the past year, has been transferred to the company's Brooklyn, N.Y., plant as foundry manager.

(Continued on page 52 P&R)

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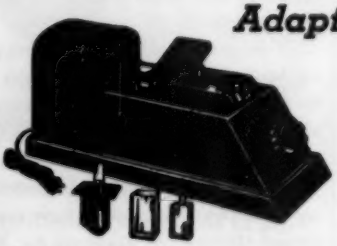

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(Continued from page 50 P&R)

William Storrie, president of the consulting engineer firm of Gore & Storrie Ltd., Toronto, died of heart failure on May 31 at the age of 72. Born at Paisley, Scotland, in 1883, he was educated at Paisley Technical College and at Glasgow & West of Scotland Technical College. He came to Toronto in 1909, where he acted as resident engineer of the city's water treatment plant. In 1913, after having served as water works engineer at Ottawa, he became chief engineer for the John verMehr Eng. Co. The firm of Gore, Nasmith & Storrie, later known as Gore & Storrie and more recently as Gore & Storrie Ltd., was organized in 1919.

Mr. Storrie was associated in the design and construction of many Canadian municipal water and sewerage projects and actively assisted in the planning of the Metropolitan Toronto water supply and sanitation system. He was also on the board of engineers which studied the water supply problems of Detroit in 1948.

A Life Member of AWWA, Mr. Storrie received the Fuller Award in 1944 from the Canadian Section, of which he was a past chairman. His outstanding contributions to the development of water and sanitation systems were likewise given recognition in the form of awards by the Federation of Sewage & Industrial Wastes Assns. and the New England Water Works Assn. Other technical societies to which he belonged include the Engineering Institute of Canada (past chairman, Toronto Branch), the FSIWA-affiliated Canadian Institute of Sewage & Sanitation (past president), and the Institution of Civil Engineers, England.

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*Woodward, 1952, EHC Activity Report 11:13 Jan.-Mar.
†Collet, Johnston, Ey, Croft, 1953 J. Amer. Public Health Assn. 43:1438-40 November.

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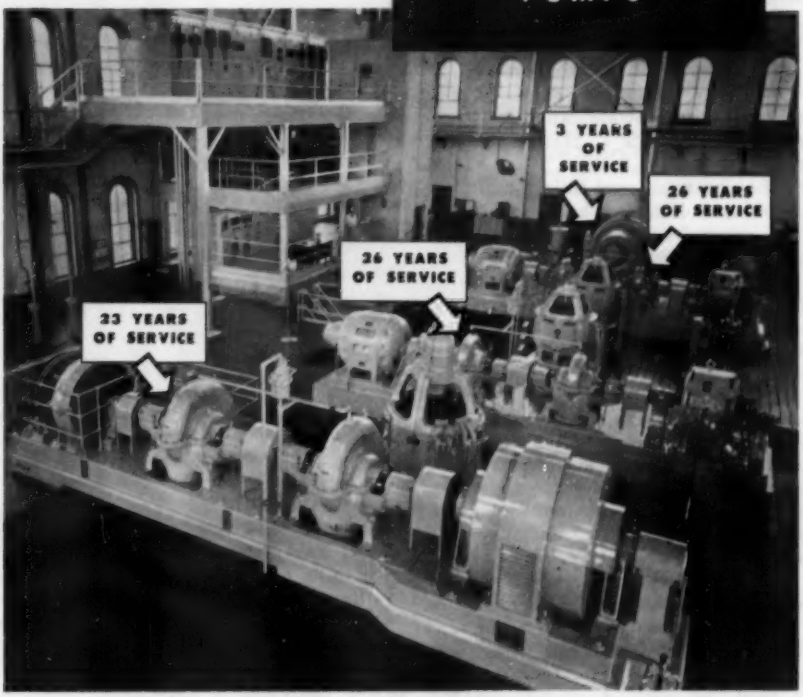

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

HYDROLOGY

The Prevention of Stratification in Reservoirs. P. Cooley & S. L. Harris. J. Inst. Wtr. Engrs. (Br.), **8**:517 ('54). In periods of rising temps. and little wind, circulation of water is limited by thermocline in storage reservoirs of Metropolitan Water Board. Lower layer of water is normally too deep to receive daylight, decaying matter falling from above reduces its oxygen content, and chem., as well as phys. stratification is set up. Accumulation of products of reduction may lead to unpleasant tastes, rendering water unfit for supply. Reservoir is being built at Walton, designed for depth of 57′. Thermal stratification problems have been anticipated, and methods for overcoming problem are discussed. Details of reservoir given, and scale model prepared for investigations. Scale effects and similarity with regard to turbulence, and mechanics of jets, are discussed. Thus, expts. on relationship between model and prototype were carried out, and studies made on dispersion and entrainment of jet discharging freely into large quant. of water. Several arrangements were tried, but most satisfactory for this reservoir was found to be 3 horizontal inlets, each 36″ diameter. This seemed to prevent thermal stratification, but in order to break down any which may form in very hot weather, further inlets should be used, pointing up from the bottom of reservoir. Practical use of inlets is discussed in detail. Conclusions reached are that thermal stratification in Walton reservoir can be dispersed or prevented, and methods suitable for this are presented. Continuous inflow is made to enter reservoir in jets. Repumping may be necessary where inflow is discontinuous, but since small inflow displaces large volumes of water, no great power is needed to turn over reservoir.—*PHEA*

Spectroscopic Determination of the Quantity of Water Vapor in the Atmosphere. T. P. Toropova. Doklady Akad. Nauk S.S.S.R. (USSR), **86**:59 ('52). Ratio of intensity of solar radiation at $\lambda = 0.94\,\mu$ to that at $\lambda = 1.01\,\mu$ was plotted against meteorological values of q, quantity of H_2O, expressed in in. of pptn, in an infinitely high column of atm. $I_{0.94\mu}/I_{1.01\mu} = 0.6$ for $q = 0.3$ and 0.15 for $q = 2.4$. Rayleigh scattering accounts for 13% of optical thickness of atm.; dry aerosols for 66%; and H_2O vapor, 21%.—*CA*

Mineralization of Ground Waters of Irrigated Regions. N. F. Fedin. Izvest. Akad. Nauk Kazakh. S.S.R. No. **121**, Ser. Geol. (USSR), No. **16**, p. 76 ('53). Purpose of study to explain the fundamental mechanism of accumulation of individual ions in ground waters and distributions according to territory. Data were worked out on more than 250 chem. analyses by statistical method of variance. Typical analyses were obtained for each separate stage of mineralization. Typical analyses were obtained for: fresh water having residue d. up to 1.0 g/l, weakly briny water with residue d. of 1.0–5.0 g/l, brine with residue d. of 5.0–10.0 g/l, and salty water with residue of 50.0–100.0 g/l. Typical HCO_3^- content varied from 375 mg/l in fresh waters to 500 mg/l for brines. In fresh waters the SO_4^{--} content was about 200 mg/l. With increase of residue d. of waters, SO_4^{--} content rapidly increased. For example, especially rapid increase of SO_4^{--} was found when residue d. exceeded 5.0 g/l. In highly mineralized brines SO_4^{--} content in typical analysis reached 23,000 mg/l. It was noticed variation curves for anions have 2 distinct max, which indicate presence of 2 fundamental types of mineralization of fresh ground water. Method of statistical variance also used for explaining general mechanism of distr. of differently mineralized

(*Continued on page 64*)

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(Continued from page 62)

ground waters according to territory. Graphs show following relations: [1] content of HCO_3^-, SO_4^{--}, and Cl^- *v.* residue d.; [2] content of Ca^{++}, Mg^{++}, $Na^+ + K^+$ *v.* residue d.; [3] variation curves for HCO_3^-, SO_4^{--}, and Cl^-; and [4] variation curves relating degree of mineralization of ground water to depth of strata.—*CA*

Dynamics of Subterranean Waters. I. I. CHEBOTAREV. Wtr. & Wtr. Eng. (Br.), **57**:186, 233, 278 (May, Jun., Jul. '53). There are 3 fundamental categories of subterranean flow through sedimentary formation: laminar, turbulent, and mixed. First is movement that takes place in sands at low veloc. Turbulent flow takes place in coarse sand and gravel where great permeability may be developed. Mixed flow of subterranean waters occurs in sediment when laminar flow takes place in one part of pore spaces and in other part turbulent flow is developed. Darcy's law can be applied only to laminar flow. It cannot be applied to sediment consisting of grains greater than 2 mm in diam. and exponent of hydraulic gradient must be less than 1. For coarse-grained sand, critical velocity of flow is equal to 0.5 cm/sec. Transition from laminar to turbulent flow occurs when velocity reaches 0.4–0.5 cm/sec. Darcy's law cannot be applied when mean size of sand grains is equal to 0.9 mm, and hydraulic gradient is as great as 1.63. Three typical cases of motion of water with free surface in homogeneous bed are distinguished by position of waterproof stratum underlying water-bearing formation: [1] water-bearing bed is sloped parallel to direction of underground flow; [2] water-bearing bed is horizontal, and [3] water-bearing bed is tilted in direction opposite to underground flow. In first case, yield is detd. by Dupuit's formula as $q = k\dfrac{h_1^2 - h_2^2}{2l}$ where k is permeability in m/day; h_1 and h_2 are level of ground water and thickness of aquifer in upper and lower cross sections of stream, resp., in meters, and l is distance in meters between cross sections. In

(Continued on page 66)

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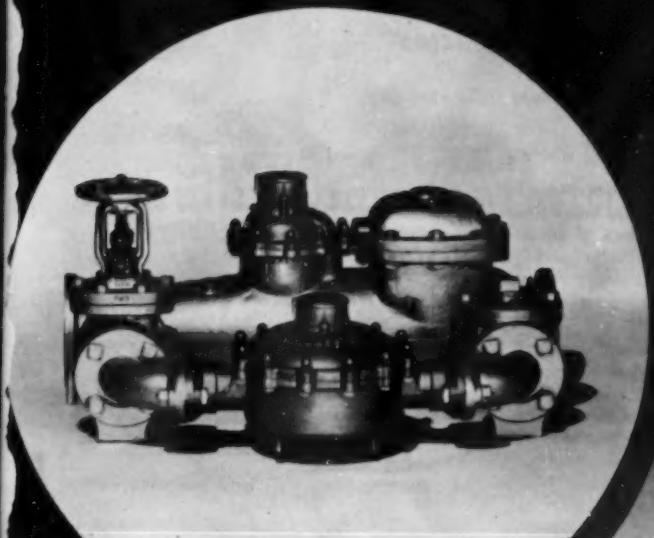

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second case, $q = k\frac{h_1 + h_2}{2}\cdot\frac{H_1 - H_2}{l}$ where q is in cu m/day. H_1 and H_2 are elevations in meters of water levels in upper and lower cross sections; h_1 and h_2 are thicknesses of aquifer in meters at upper and lower sections; and l is distance between two cross sections in meters. In third case $\frac{i_3 l}{h_{10}} = \zeta(\eta_2) - \zeta(\eta_1)$ where i_3 is slope of waterproof stratum; l is distance, in meters, between two cross sections of stream; h_{10} is "reduced" thickness of aquifer in meters detd. from equation $q = kh_{10}i$, where q is yield of underground stream per unit of cross-section area in cu m/day; η_1 and η_2 are relative thicknesses of aquifer, equal $\eta_1 = \frac{h_1}{h_{10}}$; $\eta_2 = \frac{h_2}{h_{10}}$ where h_1 and h_2, thickness of aquifer in meters, in upper and lower cross sections. Surface of water table is usually in form of ellipse expressed as $h^2 = h_1^2 + 2\frac{W}{k} \times a_1 x - \frac{W}{k}x^2$ where h is level of underground water of given cross section; h_1 is level of underground water in meters near to river from which distance x is measured; k is coefficient of permeability in m/day; w is amt. of water percolating through unit of earth's surface per unit of time, in m^3/m^3/day a_1 is distance from river to watershed of underground water and is equal to $\frac{L}{2} - \frac{k}{w} \times \frac{h_1 - h_2}{2L}$ in meters where L is distance in meters between rivers; h_2 is level of underground water in meters near second river. In general case, formula for heterogeneous bed is $q = \frac{k_{1m}h_1 + k_{2m}h_2}{2} \times \frac{H_1 - H_2}{l}$ where k_{1m} and k_{2m} mean coefficients of permeability in m/day of strata in upper and lower cross sections; h_1 and h_2 are thicknesses in meters of water-bearing bed at same cross sections; H_1 and H_2 are elevations in meters of water levels; and l is length of water-bearing bed. Method of estimating yield capacity of well is based on performance of wells that enter water-bearing formation and consist of accurate detg. discharge that can be pumped steadily at any given drawdown. Well tested is pumped at uniform rate until equilibrium has been reached and water levels in discharge and observation wells have become stationary. It is good practice to test yield capacity under two drawdowns. Yield capacity q of well is detd. by method following. Unconfined water: by pumping from single well,

$$q = 1.37\frac{ks(2H - s)}{\log R - \log r};$$

by pumping from well with one observation well, $q = 1.37\frac{k(2H - s - s_1)(s - s_1)}{\log x_1 - \log r}$; k is coef. of permeability in m/day when q is in m^3/day; H is thickness of aquifer; r is radius of well; $s = H - h$; h is height of water in pumped well; x is distance from center of well to point where hydraulic gradient is $\frac{dy}{dx}$. Pressure water: by pumping from single well, $q = \frac{ksa}{\log R - \log r}$; a is thickness of aquifer; by pumping from well with one observation well, $q = 2.73\frac{ka(s - s_1)}{\log x_1 - \log r}$. For water in interstertial rocks: unconfined water, $q = 2\pi h\sqrt{\frac{1/3(H^3 - h^3)}{\frac{1}{r} - \frac{1}{R}}}$; pressure water, $q = 2\pi ka\sqrt{sr}$.—*H. E. Babbitt*

CORROSION

Prevention of Water Corrosion. P. W. Sherwood. Mining Mag., **90**:275 ('54). 3 principal variables det. degree of corrosiveness in any instance where attack by water is concerned. They are: presence and nature of impurities, temp., and veloc. First covers enormous field, making single approach to problem impossible. O and CO_2 are most common impurities, although under certain conditions, which are outlined, each may prove beneficial in inhibiting corrosive attack. Effect of rising temp., and of presence or absence of O, is discussed. Veloc. of water flow is normally factor in increasing corrosion rates, though opposite effect is observed when replenishment of O supply induces greater passivity.—*CA*

Experience in Corrosion Control on a Products Pipeline. A. R. Murdison. Chem. Processing, **38**:8:38 (Jul. '54). Cathodic protection of 200 mi steel pipeline, largely 10–12" diam., described. Pipe coated with $\frac{1}{32}$" coal tar enamel, applied hot, into which was wrapped fiberglass, cheesecloth-like mat for tensile strength. Layer of felt paper provided protection during laying and

(Continued on page 70)

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backfilling. Continuity of coating checked with detector. Following soil resistivity surveys, and allowing for coating deterioration, 25-v, 10-amp, selenium rectifiers chosen as current source. Pipe-to-soil potential soil survey, made possible by test leads at 1-mi intervals, indicated even spacing of these along line at approx. 30-mi intervals. Ground beds consist of 10 graphite anodes located about 500′ from line, connected together 15′ apart, each rod being centered in hole 10″ in diam. and 12′ deep, with coke breeze and carbon granule backfill. Ground bed connected to rectifier and latter to pipeline with No. 8 TW cable with double-thick insulation. On completion, rectifiers turned on one by one and pipe to soil potential detd., rectifiers being adjusted to give min. of 850 mv as measured by bridge voltmeter and $CuSO_4$ electrode. Pipe-to-soil potential survey showed surprising uniformity, potentials avgg. about 1 v with rectifier outputs avgg. less than 2 amp.—*R. E. Thompson*

Corrosive Action of Tap Waters in Terms of the Equilibrium: Carbonic Acid-Calcium Oxide. A. Splittgerber. Energietech., **4**: 131 ('54). Waters poor in O and rich in carbonates do not form protective coatings in water pipes, thus leading to rapid destruction of iron, while O-rich waters of similar chem. compn. promote formation of protective coatings preventing destruction of pipes. In presence of O, primary iron oxyhydrate absorbs free and combined carbonic acid, leading to supersatd. Ca soln. at surface of Fe oxide; consequently, Ca carbonate and Fe oxide ppt. together as protective layer. In absence of O, layer of rust formed is practically free from Ca carbonate and is not protective.—*CA*

Corrosion of Iron and Steel by Aqueous Suspensions of Sulfur. T. W. Farrer & F. Wormwell. Chemistry and Industry (Br.), p. 106 ('53). Elementary sulfur is often found as product of corrosion of iron and steel, probably as result of oxidation of ferrous sulfide by atmospheric oxygen. Studies were therefore made to det. whether this elementary sulfur would stimulate further corrosion. Suspensions of sulfur in distd. water were prepared by dispersing pptd. sulfur in 5% suspension of bentonite in water. When specimens of cast iron or mild steel were immersed in suspensions, rapid uniform corrosion occurred, with formation of loose mixt. of ferrous sulfide and ferroso-ferric oxide. With suspensions contg. less than 5% sulfur, rate of corrosion was low, but with higher concns. rate of corrosion rose with increase in concn. With all concns. there was initial lag period before rapid corrosion began. At temps. below 0°C, little corrosion occurred, but with increase in temp. up to at least 55°C, there was increase in rate of corrosion. Measurement of electrode potential indicated sulfur stimulates corrosion mainly by reducing cathodic polarization. Even in suspensions contg. 50% sulfur there was no evidence of anodic polarization. It is suggested that rapid corrosion of iron and steel by elementary sulfur may be important in corrosion of buried metals under conditions which permit sulfate reduction with subsequent oxidation of sulfide, as, for instance, where fluctuations in ground water level produce anaerobic and aerobic conditions alternately.—*WPA*

The Corrosion of Domestic Galvanized Hot-Water Storage Tanks. I. L. Newell. Corrosion, **9**:2:46 ('53). Under certain conditions zinc may become cathodic to steel and accelerate corrosion of galvanized-steel hot-water storage tanks. Author reviews previous work on effects of temp., compn. of water, and particularly presence of traces of copper in water entering system on failure of zinc as protective coating. He then discusses results of studies of 6 galvanized hot-water storage tanks which were in service for 431–667 days and were fed with soft water. Tanks were connected to piping systems having components of copper or copper alloys and were equipped with magnesium rods to give addnl. cathodic protection. All tanks showed severe pitting, particularly in areas farthest from magnesium rods. Failure of tanks by leakage would be likely to occur in less than 5 yr. This was ascribed to presence of copper traces, operating temps. greater than 140°F, and presence of signif. amounts of bicarbonates and nitrates. By removing carbon dioxide and copper, by lowering operating temp. to prevent reversal of potential, and by using all galvanized systems, lower rate of corrosion could be attained. In discussion, case histories given

(Continued on page 72)

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(*Continued from page 70*)

of severe corrosion in 4 galvanized hot-water tanks; in 3 instances, corrosion is likely to have been accelerated by action of copper.—*WPA*

Case History of Failure of Marine Boiler Tubes by Stress Corrosion Cracking. R. D. BARER. Corrosion, **11**:148t ('55). Unusual type of failure of marine water boiler tubes is discussed, in which caustic cracking weakened tube so that it failed and caused partial rupture of several others. It was considered that boiler pressure was sufficient to supply stress, and that local high concns. of NaOH due to overheating were responsible for embrittlement. While such failures are rare, they can be prevented by avoiding clogging of flue gas passages which apparently channel hot gases and by using alternative feedwater treatments without NaOH.—*CA*

Evaporator Corrosion. K. WICKERT. Mitt. Ver. Grosskesselbesitzer (Ger.), No. **33**:408 ('55). Corrosion of raw-water surfaces of tubes in vertical boiler water makeup evaporator found due to low level of raw water in evaporator. Feedwater treatment used included phosphates and NaOH. Droplets of water were splashed onto upper surface of evaporator tubes and became concd. solns. of NaOH, capable of corroding steel tube surfaces, as concd. soln. ran down tubes. This corrosion was minimized by carrying water level in evaporator as high as nature of water permitted. Evaporator tubes of Cu show same type of corrosion under low water conditions. Evaporator supplied with condensate of low salt content and with same addn. of phosphate and NaOH, but with very high water level, suffered only slight corrosion.—*CA*

Steam Decomposition, Protective-Layer Formation, and Corrosion. H. E. HOMIG. Mitt. Ver. Grosskesselbesitzer (Ger.), No. **33**:416 ('55). Pure thermal splitting of steam to H and O takes place to very small extent at boiler superheater temps. used at present. Mechanism of reaction of Fe with

(*Continued on page 74*)

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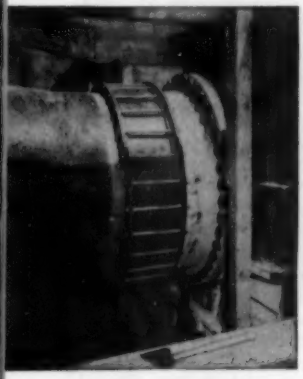

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steam is reviewed. In normal boiler operation, layers of Fe_3O_4 of several tenths of mm are formed after few yr in graphs are shown of thickness up to 10 yr for operating temps. up to 700°. On basis of certain assumptions, amt. of H formed by process is also calcd. and shown in graphs. When protective film is injured or destroyed by mech., thermal, or chem. means, rate of steam decompn. as measured by H content of steam will suddenly increase above anticipated max. of 10^{-2} ppm.—*CA*

Soft-Water Corrosion and Calcium Carbonate Saturation. G. R. ATKINS. S. African Ind. Chemist, **8**:104 ('54). Account is given of studies on corrosion of metals and cement by soft waters of coastal belt of Cape Province, USA, which have pH value of 4.6–5.2 and are deficient in calcium salts. Treatment of water by coagulation to remove organic coloring matter and addition of lime to raise pH value to 9.5 and total alky. to 10.0 ppm made it noncorrosive to lead and copper but not to iron and zinc. Calcium carbonate satn. curve was plotted for treated water and this showed it would be impossible by adding slaked lime to produce water supersatd. with calcium carbonate. To attain supersatn., alky. of water was raised to 35–40 ppm and pH values to 9.3 by carbonating after addn. of lime. Test sections of main carrying this water were not corroded after 18 mo. and were coated uniformly with thin layer of calcium carbonate. Water was still corrosive to zinc in brass fittings. Effect on corrosion of zinc of varying alky. and pH value of water while keeping concn. of chlorides and sulphates constant was studied. Increase in pH value of water, concn. of zinc in water and loss in weight of specimen were observed. With alky. of 25 ppm or over, rate of corrosion increased initially and then decreased roughly in proportion to alky. When alky. was 10 ppm after temporary decrease corrosion rate continued to rise and distinct pitting was observed. In general there was increase in corrosion with increasing pH value, particularly above pH 8.5, and this effect was more marked at higher alkalinities. These waters have proved corrosive to cement-lined mains; calcium compounds are leached out from cement and loosened sand rapidly disintegrates. Organic matter in water exerts protective effect by depositing on surface and binding together sand grains. Protective compds. incorporated in cement exerted only initial slight protective effect. Water treated to give alky. of 36 ppm and pH value of 8.4 did not attack cement; increase in pH value alone did not prevent attack.—*WPA*

SOFTENING AND IRON REMOVAL

Desalting Brackish Waters With Ion-Exchange Resin Membranes. T. R. E. KRESSMAN. Ind. Chemist, **30**:99 ('54). Salt water is treated in multicompartmental electrodialysis cell which, in simplest form, consists of 2 oppositely charged electrode compartments sepd. by middle compartment. Water in middle compartment is demineralized by flow of mineral anions and cations to electrode compartments. Current efficiency is increased by substituting ion-exchange membranes for usual porous compartment partitions; this prevents counterflow of H and OH ions. Overvoltage is reduced by employing cell composed of up to 100 compartments. In such a cell, where anion-selective partitions alternate with cation-selective partitions, every other compartment is demineralized, and intervening compartments are enriched in minerals. Method reduces economically salt content of water to below about 500 ppm. Further practical demineralization would require subsequent conventional ion-exchange methods. Work demonstrates tech. feasibility of supplying drinking and irrigation water to arid places of world, though accurate cost data are lacking at present.—*CA*

Demineralization of Water Through Ion Exchange. J. BUCHI & M. SOLIVA. Pharm. Acta Helv. (Switz.), **29**:221 ('54). Study indicates it is possible to produce H_2O corresponding to distd. H_2O of Swiss Pharmacopeia V by means of ion-exchange resins in mixed-bed process on small scale if filter tubes are not too narrow in diam. App. is described. Mixed-bed column is preferred since amines from anion exchanger can be resorbed by cation exchanger. Detn. of Cl can be used as indication of exhaustion of masses. Continuous process is not necessary although it is advisable to throw away first fractions if process has been interrupted;

(*Continued on page 76*)

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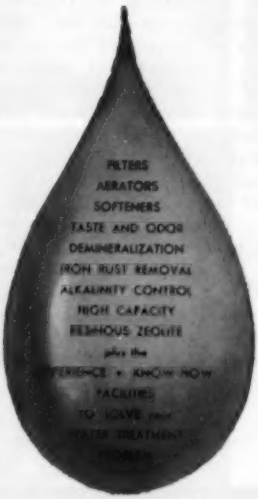

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That's why more and more industries and municipalities are installing General Filter water treatment plants. They know they can depend on General Filter to solve their problem the *right* way. No job is too big or too small. General Filter's field-trained water specialists will *prescribe* a plant . . . its experienced engineers will *design* it and its skilled construction engineers will *build* it to fit your needs *exactly*.

Find out how General Filter solves Water Treatment problems for Industries and Municipalities . . . Find out how General Filter can solve yours.

Write today for complete information . . . no obligation . . .

General Filter Company

AMES, IOWA

"yours for better water"

(*Continued from page 74*)

however, it is advisable to select size of app. that will produce amt. needed in 1 uninterrupted process.—*CA*

Mixed-Bed Demineralizers the Answer for Albany Station. T. FINNEGAN & D. MILLER. Elec. Light and Power, **32**:118 ('54). Automatically regenerated mixed-bed demineralizer was selected in preference to evaporators at Albany station, based on estd. cost savings. Operational results to date have been better than guarantee values. Makeup at this station is relatively low; under such conditions, 2-bed demineralizer would give water of high cond. for considerable period after starting. Effluent from mixed bed shows low cond. within a min. after starting. Controls are provided for automatic shutting down units when cond. of water becomes excessive. End point for mixed-bed units is quite sharp and distinct, with marked increase in cond. Comparative costs are given for evaporators as against demineralizers. Same system, with slight modifications, will be installed at Huntley station.—*CA*

Mixed-Bed Deionization at High Flow Rates. J. R. CADDELL & R. L. MOISON. Chem. Eng. Progr. Symposium Ser., **50**:14:1 ('54). Design of mixed-bed ion-exchange equipment for deionization of water need not be limited to low flow rates, about 5 gpm/sq ft, usually employed in water softening. With beds of mixed strong-acid and strong-base ion-exchange resins, increasing flow rate from 5 to 100 gpm/sq ft at any fixed level of influent impurities did not affect capac. for producing pure water with specific resistance of 10^6 ohm-cm or better from a feed contg. principally $Al(NO_3)_3 \cdot 9H_2O$ as impurity. Raising influent concn. from 3 to 192 ppm, however, almost doubled ion-exchange capacity expressed in terms of impurities retained by resins.—*CA*

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For almost a century Cole elevated tanks have been helping provide uniform water pressure, fire protection and adequate water reserve in scores of American cities.

Capacities 5,000 to 2,000,000 gallons—with hemispherical, ellipsoidal or conical bottoms. Also flat-bottom tanks for standpipe storage. Correctly built in accordance with AWWA specifications.

We invite your inquiries. State capacity, height to bottom, and location.

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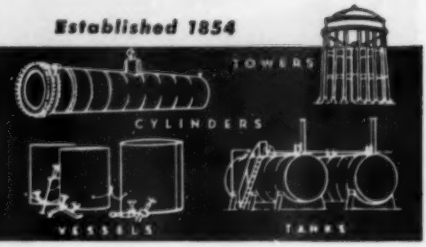

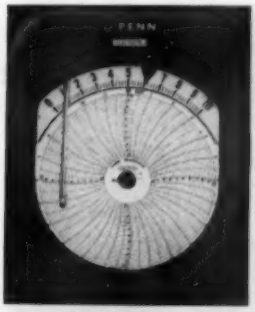

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RECORDERS
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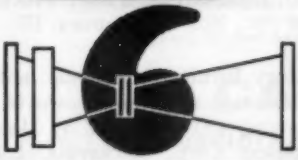
Liquid Level
Loss of Head
Pressure
Temperature
Pump Operation
TELEPHONE LINE TRANSMISSION

The origin of Penn's present line of instrumentation goes back to 1909 when Cochrane meters were introduced. One of the earliest testing programs for open channel flow measurement was undertaken to develop these meters as reported at the 1914 A.S.M.E. meeting.

In 1918, an improved mechanical flow meter with no stuffing box was developed and in 1935 the first null-balance, servo-powered electric meter was produced. Hundreds of these meters have been installed in water works service, many for over 30 years.

HIGHEST REPRODUCIBLE ACCURACY distinguishes Penn meters. Such accuracy is achieved only by a null-balance, servo-powered electric meter. To this unexcelled high fidelity of electrical transmission and recording, Penn adds the additional refinement of a calibration cam. This cam precisely matches the calibration of the recorder-totalizer with that of the differential producer. The result is "matched metering" and higher over-all accuracy.



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DIVISION OF BURGESS MANNING COMPANY

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DRILL WITH SPINKS

FOR HIGHER CAPACITY WELLS

SPECIAL MUDS MINED AND PROCESSED FOR WATER WELL DRILLING!

- **SPINKS Gleason**—easy-mixing mud, washes out quickly, easily. Minimum penetration! Makes heavy mud — 9.5-lb. to 10-lb. range — stops cave-ins! Excellent lubrication properties! Removes cuttings quickly, thoroughly! Durably sacked in water-repellent asphalt lined bags! 50-lb. size for easy handling . . . less chance of loss!
- **SPINK-Gel** — high-yielding, finest quality Wyoming bentonite. Low water loss! Exceptional lubricating qualities!
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Distributorships now open in several choice territories! WRITE, WIRE or CALL Rich Carothers. Telephone 1502, Paris, Tenn.

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Mines and General Offices
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Spinks

Service Lines

Builders-Providence, a division of B-I-F Industries, Inc., announces the publication of several new bulletins: "Instrumentation and Control for Water Filtration Plants" (Bul. 100-K2A), 16 pages; "Pneumatic Flow Meters" (Bul. 285-G2A), 4 pages; "Synchro-Scan Supervisory Control" (Bul. 240-M6), 4 pages; and a supplementary bulletin (Bul. 285-L2A) on the "BalanCel Pneumatic Transmitter, Model AT-SD," 4 pages. These can be obtained from Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I.

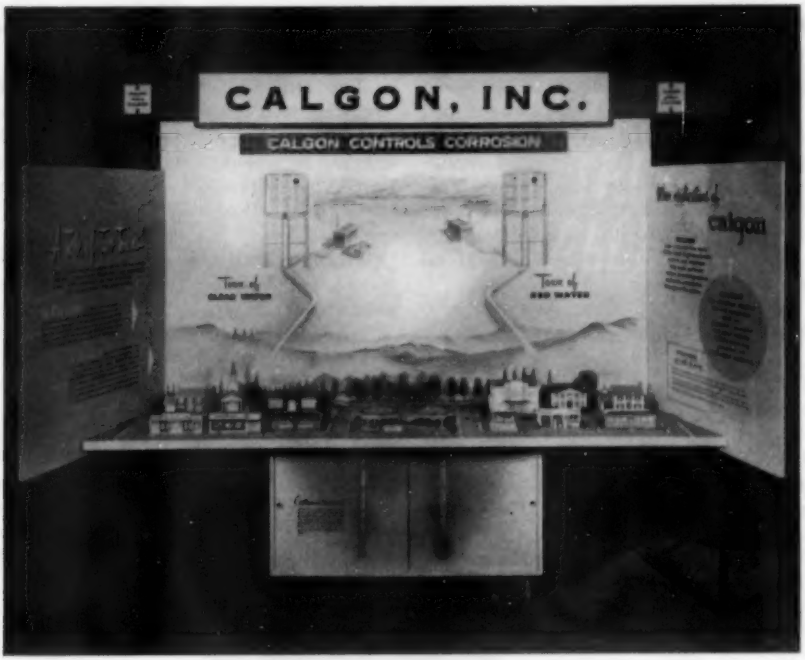
Wrought-iron pipe costs are compared with those of other types in an 8-page booklet, "True Piping Economy," issued by A. M. Byers Co., Clark Bldg., Pittsburgh 22, Pa.

Waste water clarification with the flocculating agent, "Lytron 886," identified as a partial calcium salt of a carboxyl containing high-molecular-weight copolymer, is described in a 16-page bulletin (No. 1008) available from Plastics Div., Monsanto Chemical Co., Springfield, Mass.

Sludge-collecting equipment for circular or square tanks—including tractor drive units and pier- and bridge-supported mechanisms—is the subject of Bul. 9W65 (16 pages), published by Walker Process Equipment Inc., Box 266, Aurora, Ill.

Laboratory furniture, sectional units, sinks, and storage cases are shown in a 12-page catalog (SD-3) issued by Metalab Equipment Corp., Hicksville, L.I., N.Y.

(Continued on page 80 P&R)



TOWN FIGHTS "RED" MENACE!

Visitors to the recent AWWA convention saw how the town of "Clear Water" rid itself of the Red Water Problem with Calgon* Threshold Treatment

This graphic display showing how Calgon works demonstrated a method of water control familiar to water works superintendents from coast to coast. They know from experience that Calgon not only stabilizes dissolved iron and manganese (preventing red or black water) but also controls corrosion† and tuberculation by forming a protective film on metal surfaces.

Calgon is effective against lime scale formation, too, and stabilizes lime soda softened water to control calcium carbonate precipitation.

Many years of experience with the water conditions all over the country are at your service. Write or phone for information about your particular problem.

*Calgon is the Registered Trade Mark of Calgon, Inc. for its glassy phosphate (sodium hexametaphosphate) products.

†Fully licensed for use under U.S. patent 2,337,856 and 2,304,850.

CALGON, Inc.

A SUBSIDIARY OF HAGAN CORPORATION

HAGAN BUILDING PITTSBURGH 30, PA.

Service Lines

(Continued from page 78 P&R)

A microflow, controlled-volume pump of the piston diaphragm type is described in a 4-page bulletin (No. 500) issued by Lapp Insulator Co., Inc., Process Equipment Div., 10 Gilbert St., LeRoy, N.Y. The "Pulsafeeder" pump is said to operate against pressures up to 1,000 psig and has a maximum flow rate of 2,400 ml per hour.

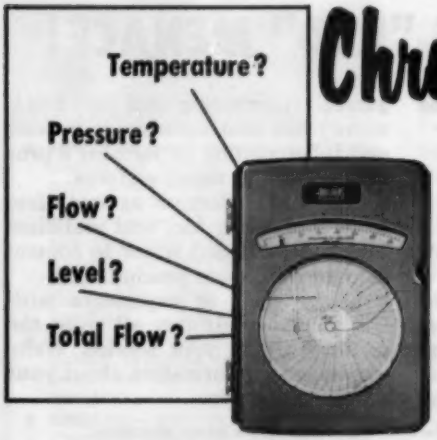
Two new bulletins have been released by Allis-Chalmers Mfg. Co.: Bul. 52B6083C describes Model C-3 supporting adapter "Electrifugal" pumps, up to 2,500-gpm capacity and 400-ft head; Bul. 20B6082C covers stationary and motion control "Vari-Pitch" sheaves for speed variations up to 76 per cent (1–600 hp). Copies are available on request from the company, 1026 S. 70th St., Milwaukee, Wis.

The Dowell acidizing service for increasing well yield by enlarging formation channels and removing scale is described in a 4-page brochure. Requests should be addressed to Advertising Dept., Dowell Inc., Box 536, Tulsa 1, Okla.

Storage and maintenance equipment —lockers, ladders, shelving, intercom units, and other items—is listed in an illustrated 16-page catalog available from Precision Equipment Co., 3666 Milwaukee Ave., Chicago 41, Ill.

Two-stage pumps (Type DMD) for high-head applications, with 2–10-in. discharge and capacities up to 4,000 gpm, are the subject of Bul. C-1054 (4 pages), issued by C. H. Wheeler Mfg. Co., Economy Pumps Div., 19th & Lehigh, Philadelphia 32, Pa.

(Continued on page 82 P&R)



Chronoflo brings you the answers

By transmitting and receiving information over a simple two-wire circuit, Builders CHRONOFLO TELEMETERS produce important economies for water and sewage plants.

(1) Chronoflo saves time—gives immediate indications of changes in flow, total flow, pressure, temperature, level.

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Chronoflo is one of the many Builders systems for modern plant operation. Write for Bulletin 230-H4. Builders-Providence, Inc., 365 Harris Avenue, Providence 1, Rhode Island.

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Service Lines

(Continued from page 80 P&R)

A line-operated pH meter, Model 110, which has a 7-in. scale length and covers the entire range from 0 to 14 pH without switching and without reversal of the pointer travel, is described in an 8-page bulletin (No. 105) issued by Photovolt Corp., 95 Madison Ave., New York 16, N.Y.

De-aeration with a stainless-steel, jet atomizing unit, featuring countercurrent two-stage action, is the subject of a 4-page bulletin (No. 102) available from L.A. Water Softener Co., 1007 Air Way, Glendale 1, Calif.

Precision-bore glass, quartz, and "Vycor" tubing in various shapes and sizes, for use in high-accuracy manometers, viscosimeters, and other glass instruments where internal dimensions are critical, is listed in a 4-page stock catalog (No. 80-20) issued by Fischer & Porter Co., 379 Jacksonville Rd., Hatboro, Pa.

Remote-bulb, adjustable temperature controller specifications are given in a 2-page bulletin available from Fenwal Inc., Ashland, Mass.

Diatomite filtration for potable, swimming pool, and process water supplies, using "Celite" (diatomaceous silica), is described in a 12-page brochure available from Celite Div., Johns-Manville Products Corp., 22 E. 40th St., New York 16, N.Y.

Cracking and embrittlement damage is discussed in an 8-page booklet published by Hall Labs., Inc., 323—4th Ave., Pittsburgh 30, Pa.

Cation-exchange softeners with flow rates from 6.5 to 40 gpm, to provide small volumes of water for industrial use, are being marketed by Industrial Filter & Pump Mfg. Co. The units, designed for either automatic or semiautomatic operation, are described in a 4-page bulletin (No. 210) available from the company, 5900 Ogden Ave., Chicago 50, Ill.

Synthetic-rubber calking compounds and other types of synthetic protective coatings are described in a bulletin issued by David E. Long Corp., 220 E. 42nd St., New York 17, N.Y.

Radiographic-fluoroscopic units, both portable and heavy duty, for examination of materials and assemblies, are illustrated in a 4-page bulletin ("Norelco MG 60") available from Research & Control Instruments Div., North American Philips Co., 750 S. Fulton Ave., Mount Vernon, N.Y.

Buying information on standard a-c fractional- and integral-horsepower motors is given in a 28-page catalog (GEC-1026) issued by General Electric Co. Photographs, ratings, book prices, and other selection and purchase data are included. The catalog can be obtained from the company at Schenectady 5, N.Y.

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Well Washed and Carefully Graded to Any Specification.
Prompt Shipment in Bulk or in Bags of 100 lb. Each

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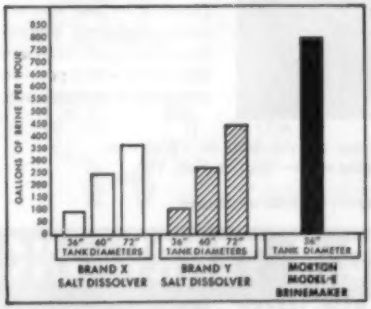
Save money with a Morton Model-E Brinemaker!

(Brinemaker not available on West Coast)

The Morton Model-E Brinemaker delivers up to 800 gallons of saturated brine per hour . . . the only one that needs no space-wasting storage tank.

The Morton Model-E Brinemaker also makes it possible to expand your brine installation with a minimum of added expense. The tremendous brine-producing capacity may well cover increased needs without the added expense of installing more units.

You put money in your pocket when you put a Morton Brinemaker in your plant, because you save man hours by pumping instead of hauling salt to the areas where it is needed.



Comparative Performance: Morton and Competitive Salt Dissolvers

Look how much more brine the Morton Model-E gives

Competitive rock salt dissolvers have less than one-half the capacity even when they're twice as large.

The Morton Model-E is the only brinemaker specially designed to produce brine from readily available, high purity, Morton evaporated salt; and you get a continual supply of clean, high-quality, saturated brine. No time or man hours are lost in cleaning out sludge and other impurities when you use the Model-E.

For more information about the Model-E and other Morton Brinemakers, or for expert, on-the-spot help with any brinemaking problem, write:

MORTON SALT Company

Industrial Division, Dept. JA-4,
120 South La Salle Street, Chicago 3, Illinois

CHANGES IN MEMBERSHIP

NEW MEMBERS

Applications received June 1–30, 1955

Abouzaghia, Fouad I., Asst. Director of Work, Ministry of Municipality & Rural Affairs, 15 Eksheed St. Roda, Cairo, Egypt (Jul. '55) *RPD*

Acebes, Lucien, Pres., Harbor Oaks Improvement Assn. Inc., Box 449, Port Orange, Fla. (Affil. Jul. '55) *MP*

Aung-Kywe, Asst. Engr., San. Div., National Housing Board of the Union of Burma, Box 242, Rangoon, Burma (Jul. '55) *RPD*

Baker, Edward D., Contractor, Baker Brothers Constr. Corp., 17 Hayes St., Elmsford, N.Y. (Jul. '55) *D*

Baker, Joe E., Water Plant Operator, Redstone Arsenal, Huntsville, Ala. (Jul. '55) *MRPD*

Becker, Eugene B., Supervisor, Water Plant, West Palm Beach Water Co., 440 Clematis Ave., West Palm Beach, Fla. (Jul. '55) *MPD*

Bell, Fred S., Jr., Engr., Public Health Dept., 128 W. Commerce St., San Antonio, Tex. (Jul. '55) *RP*

Berberich, Richard G., Cadet Engr., American Water Works Service Co., 3 Penn Center Plaza, Philadelphia 2, Pa. (Jul. '55) *MP*

Bowman, R. A., Clerk, Augusta County Board of Supervisors, Box 604, Staunton, Va. (Jul. '55) *MD*

Bradley, H. C., Owner, Meter Repair Service, 323 Engel St., Houston, Tex. (Jul. '55) *M*

Branom, Ray H., Pres., Instrument Sales Co., Inc., 2137—2nd Ave., Seattle, Wash. (Jul. '55) *D*

Carpenter, James Donald, Vice-Pres., Gannett, Fleming, Corddry & Carpenter, Inc., 600 N. 2nd St., Harrisburg, Pa. (Jul. '55) *MRPD*

Catasauqua Water Dept., Jacob Stocker, Chairman, Fire & Water Com., 118 Church St., Catasauqua, Pa. (Corp. M. Jul. '55) *M*

Coerver, James F., Public Health Engr., State Dept. of Health, 207 Civil Courts Bldg., New Orleans, La. (Jul. '55) *MRP*

Cooney, Thomas J.: *see* Yonkers (N.Y.) Dept. of Public Works

Danzer, Ronald E., Civ. Engr., Water Div., 1640 S. Kingshighway Blvd., St. Louis 10, Mo. (Jul. '55) *M*

de Laureal, W. David, Cons. Engr., de Laureal & Moses, 201 Nola Bldg., New Orleans, La. (Jul. '55) *MRP*

Demopulos & Ferguson, Cons. Engrs., B. M. Ferguson, Partner, 212 Johnson Bldg., Shreveport, La. (Corp. M. Jul. '55) *RPD*

Dismukes, Douglas E., Jr., Field Engr., Fischer & Porter Co., 29 Bala Ave., Bala Cynwyd, Pa. (Jul. '55) *PD*

Ferguson, B. M.: *see* Demopulos & Ferguson

Gaines, Henry U., Jr., Supt. of Utilities, Box 107, Las Cruces, N.M. (Jul. '55)

Galloway, B. E., Cons. Engr., Roessle & Galloway, 3012 Metairie Rd., Metairie, La. (Jul. '55)

(Continued on page 86 P&R)

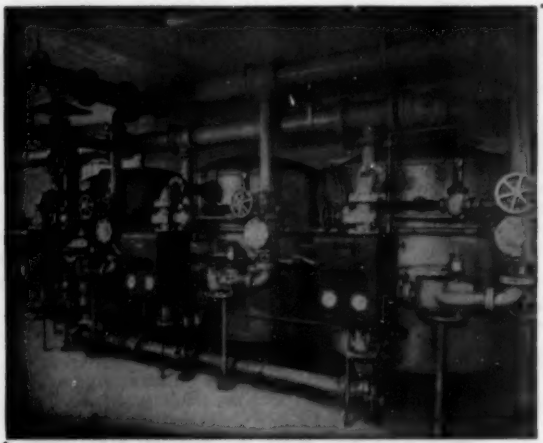


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Photo on left shows a typical H & T fully automatic, municipal, zeolite water softening plant producing clear, iron free, soft water.

Operation of this automatic water treatment plant is by our electrically operated *poppet* type multiport valves—the valves which provide unequalled performance.

If you have a water problem of any size or type—write us. With over 50 years of experience—conditioning water—We Can Help You

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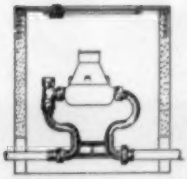
To Simplify

OUTDOOR METER SETTINGS



With a Ford Coppersetter, or a Ford Linesetter, you can eliminate as many as six pipe joints, two risers, four ells, one pipe coupling, one meter coupling and possibly a valve. In so doing, you raise your meter from 3″ to 36″ above your service line, depending upon the model used. Positive alignment is maintained when meters are changed.

Copper and bronze construction add extra years of life. Hydraulic efficiency is improved.

The economy is obvious . . . . and the savings are real. Send for free catalog. It contains complete information.

FOR BETTER WATER SERVICES

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THE FORD METER BOX COMPANY, INC. Wabash, Indiana

(Continued from page 84 P&R)

Gallup Water Dept., G. William Petranovich, Supt., Gallup, N.M. (Corp. M. Jul. '55) *MP*

Giles, Glenn, Water Supt., 403 E. Chestnut St., Mowequa, Ill. (Jul. '55) *MP*

Gupta, B. N. P., Exec. Engr., Northern Railway, Baroda House, New Delhi 1, India (Jul. '55)

Haggard, W. O., Gen. Mgr., Central Service Assn., Box 377, Tupelo, Miss. (Jul. '55) *M*

Hansen, A. E., Director, Works Dept., 74 Carmarthen St., St. John, N.B. (Jul. '55)

Hansen, Helmer, Atty., Ross & O'Keefe, 122 S. Michigan Ave., Chicago, Ill. (Jul. '55) *M*

Hasselback, James C., Supt., Water Dept., 543 Converse St., Corunna, Mich. (Jul. '55) *M*

Henry, Ross, Sales Engr., Rockwell Mfg. Co., 122 S. Michigan Ave., Chicago, Ill. (Jul. '55)

Isaac, Paul H., Partner, Hammond, Collier & Isaac, 4010 Stone Way, Seattle 3, Wash. (Jul. '55) *RPD*

Jefferson, J. J., Civ. Engr., Ripple & Howe, 833—23rd St., Denver, Colo. (Jul. '55) *PD*

Jennings, R. M., Director of Public Works, City Hall, Texas City, Tex. (Jul. '55) *M*

Lake, R. E.; *see* Whirlpool Corp.

Loehr, Raymond C., Instructor, Civ. Eng. Dept., Case Inst. of Technology, 10900 Euclid Ave., Cleveland 6, Ohio (Jul. '55) *P*

Lollis, Robert L., Salesman, Lynchburg Foundry Co., Drawer 411, Lynchburg, Va. (Jul. '55)

Lynn, Walter R., Asst. Prof., Civ. Eng., Univ. of Miami, Coral Gables, Fla. (Jul. '55)

McCauley, Robert F., Assoc. Prof., Civ. & San. Eng., Michigan State Univ., East Lansing, Mich. (Jul. '55) *MP*

McFarland, William, Supt., Water Works, Lynn, Ind. (Jul. '55) *M*

McNelis, Hugh J., Salesman, Simplex Valve & Meter Co., 53 W. Jackson Blvd., Chicago, Ill. (Jul. '55)

Meyers, Walter A., Distr. Supt., Water Dept., Elyria, Ohio (Jul. '55) *D*

Mowrey, William R., Pumping Supt., Southern California Water Co., 1218 W. El Segundo Blvd., Gardena, Calif. (Jul. '55) *MRP*

Mumma, Roy M., Civ. Engr., Water Dept., 605 Lincoln Bldg., Cleveland 14, Ohio (Jul. '55) *M*

Nichols, James R., Civ. Engr., Freese & Nichols, 407 Danciger Bldg., Fort Worth, Tex. (Jul. '55) *RP*

Orlob, Gerald T., Asst. Prof., Civ. Eng., Rm. 10 Engineering Bldg., Univ. of California, Berkeley, Calif. (Jul. '55) *RPD*

Pearce, Albert E., Power Supt., West Virginia Pulp & Paper Co., Charleston, S.C. (Jul. '55) *PD*

Petranovich, G. William; *see* Gallup (N.M.) Water Dept.

Preisler, Donald R., Civ. Engr., Water Constr. Div., Plant Design Sec., City Hall, 200 E. Wells St., Milwaukee, Wis. (Jul. '55) *PD*

Putnam, Philip H., Pres., Fluid Controls Co., Inc., 5150 Ridge Ave., Philadelphia 28, Pa. (Jul. '55) *D*

Rice, George P., Cons. Engr., Audubon Bldg., New Orleans 16, La. (Jul. '55) *RPD*

Roessle, Everett G., Cons. Engr., Roessle & Galloway, 3012 Metairie Rd., Metairie, La. (Jul. '55) *RP*

Ryan, Edward T., Meter Reader, Water Finance Dept., 301 N. Andrews Ave., Fort Lauderdale, Fla. (Jul. '55) *M*

Susse, Bruce E., Director of Eng., Water Board, San Antonio, Tex. (Jul. '55) *MR*

Schuring, Toney, Street & Water Com., 417 E. Comm Ave., Lowell, Ind. (Jul. '55) *MRPD*

(Continued on page 88 P&R)

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Type SM with Worm Gear Drive on R-S Butterfly Valve.

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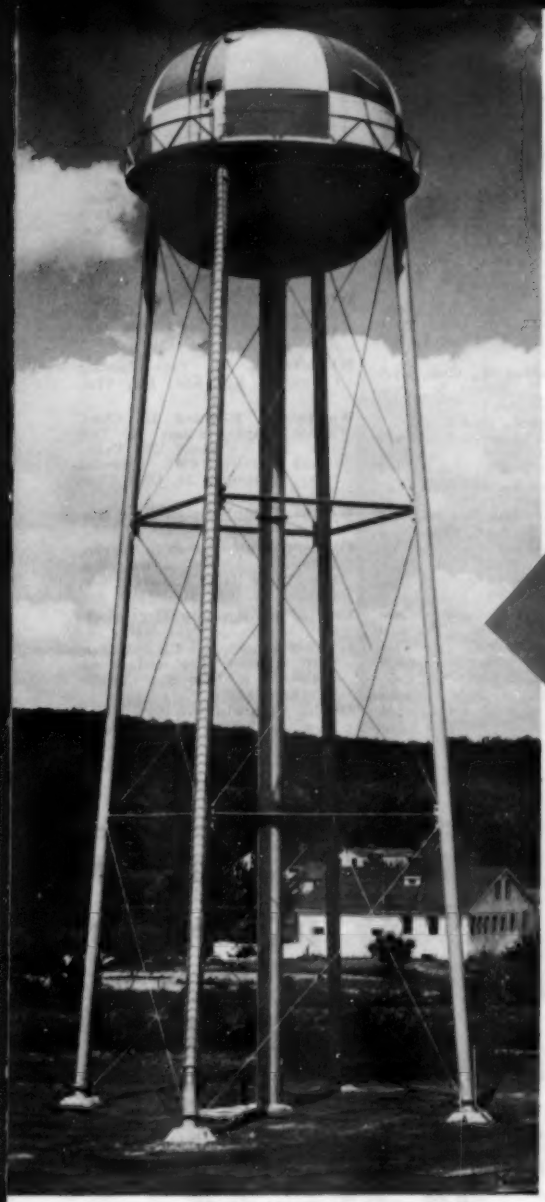

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(Continued from page 86 P&R)

Simmons, Jack H., Civ. Engr., Freese & Nichols, 407 Danciger Bldg., Fort Worth, Tex. (Jul. '55) *RP*

Smith, Charles H., Repr., J. B. McCrary Co., Inc., Box 72, Thibodaux, La. (Jul. '55)

Smith, James R., Supt. of Pumping, Louisville Water Co., 435 S. 3rd St., Louisville 2, Ky. (Jul. '55) *D*

Snider, Irving John, Sales Engr., Manufacturers Processing Co., Box 6, Detroit, Mich. (Jul. '55) *RP*

Specht, Dale L., Water Leadingman, Water Dept., 505 W. 14th St., The Dalles, Ore. (Jul. '55) *P*

Stocker, Jacob; *see* Catasauqua (Pa.) Water Dept.

Sullivan, William T., Field Repr., National Aluminate Corp., Box 1263, Greensboro, N. C. (Apr. '55) *RP*

Terry, William G., Sales Repr., Hersey Mfg. Co., 510 Haas-Howell Bldg., Atlanta, Ga. (Apr. '55)

Thayer, Herbert G., Supt., Munic. Utilities, Geneseo, Ill. (Jul. '55) *M*

Thorpe, Thomas L., Asst. Dist. Supt., Southern California Water Co., 1218 W. El Segundo Blvd., Gardena, Calif. (Jul. '55) *D*

Towner, B. G.; *see* Paris Township (Mich.) Water Dept.

Troilier, Howard R., City Supervisor, Box 189, Goldendale, Wash. (Apr. '55) *M*

Ulmer, Blaine A., Chief Engr., Patton Equipment Co., Inc., 2333 S. Hanley Rd., St. Louis 17, Mo. (Apr. '55) *PD*

Voyles, Donald E., Chem. Engr., Steam Power Div., Duke Power Co., Box 2178, Charlotte 1, N.C. (Jul. '55) *P*

Wagner, Warren O., Cons. Hydr. Engr., 738 E. Walnut St., Pasadena 4, Calif. (Apr. '55) *RPD*

Weaver, Paul J., Jr., Research & Development Dept., Procter & Gamble Co., M A & R Bldg., Cincinnati 17, Ohio (Jul. '55) *P*

Webb, Robert L., Jr., City Engr., Water Supt., City Hall, El Segundo, Calif. (Apr. '55) *MD*

Whetsler, C. F., Supt., Filter Plant, Washington Water Power Co., Box 71, Clarkston, Wash. (Jul. '55) *P*

Whirlpool Corp., R. E. Lake, Mgr., Research & Development Eng., 300 Broad St., St. Joseph, Mich. (Corp. M. Jul. '55) *RPD*

White, C. Bernard, Jr., Cons. Engr., 2777—14th St., Sacramento 18, Calif. (Jul. '55)

Whitney, John S., Supt., Community Utilities Corp., 8421 S.W. 27th St., Miami 44, Fla. (Jul. '55) *MPD*

Willis, Raymond C., Chief Operator, Munic. Pumping Stn., 1515 Burns St., Palatka, Fla. (Apr. '55) *P*

Wilson, Charles C., Supt., Public Works, Clinton, Mich. (Apr. '55)

Wilson, Paul D., Field Engr., Fairbanks, More & Co., 443 W. 4th St., Lexington, Ky. (Jul. '55) *PD*

Winders, A. H., Tank Painting Contractor, Red Key, Ind. (Jul. '55)

Woodward, Richard L., Chief, Water Supply, Robert A. Taft San. Eng. Center, US Public Health Service, 4676 Columbia Pkwy., Cincinnati 26, Ohio (Apr. '55) *P*

Wright, Campbell; *see* Reed Mfg. Co.

Yonkers Dept. of Public Works, Thomas J. Cooney, Comr., Rm. 311, City Hall, Yonkers, N.Y. (Munic. Sv. Sub. Jul. '55)

York, Paul A., City Mgr., Rockford, Mich. (Apr. '55) *MD*

Zeid, Sydney L., Civ. & San. Engr., Consoer, Townsend & Assocs., 351 E. Ohio St., Chicago, Ill. (Apr. '55) *P*

Ziskin, Harold, Water Chem. Engr., South Dist. Filtration Plant, Chicago, Ill. (Jul. '55)

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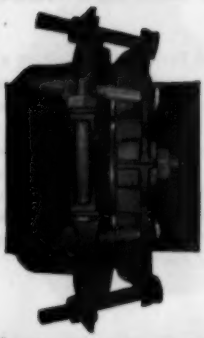

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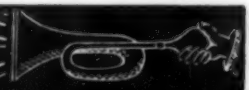

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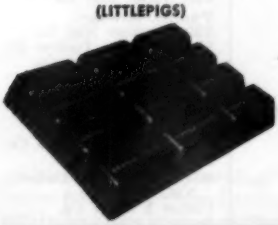

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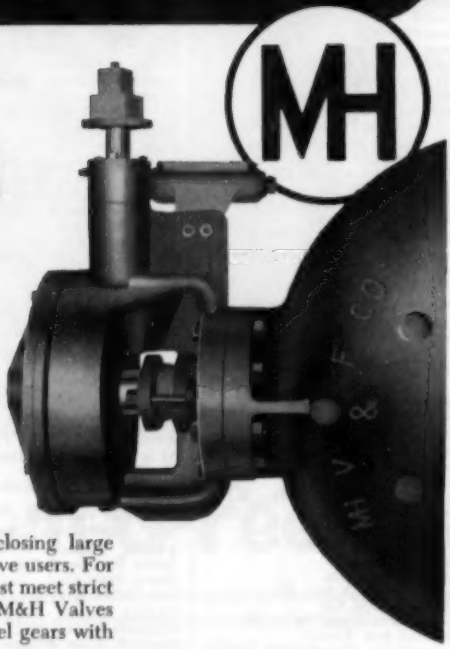

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Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

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Ross Valve Mfg. Co., Inc.

Valves, Gate:
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Dresser Mfg. Div.
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Ludlow Valve Mfg. Co., Inc.
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Rensselaer Valve Co.
A. P. Smith Mfg. Co.
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Henry Pratt Co.
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Valves, Swing Check:
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Darling Valve & Mfg. Co.
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M & H Valve & Fittings Co.
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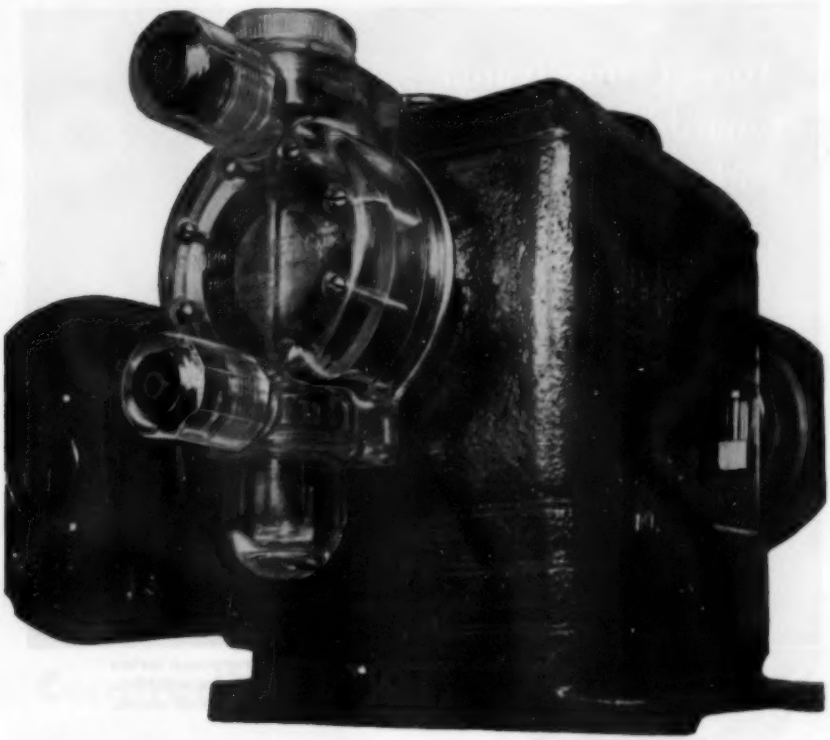
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.



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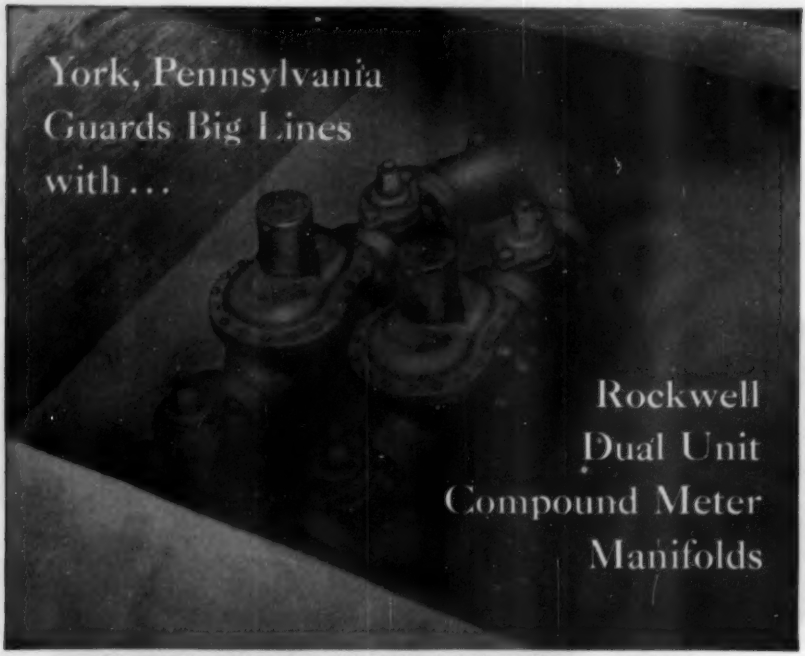

This assembly consists of two 4-in Rockwell single register compound meters complete with four Fig. 143 Nordstrom valves and two 8-in reducing manifolds. The laying length conforms to A.W.W.A. standards for 8-in compound meters.

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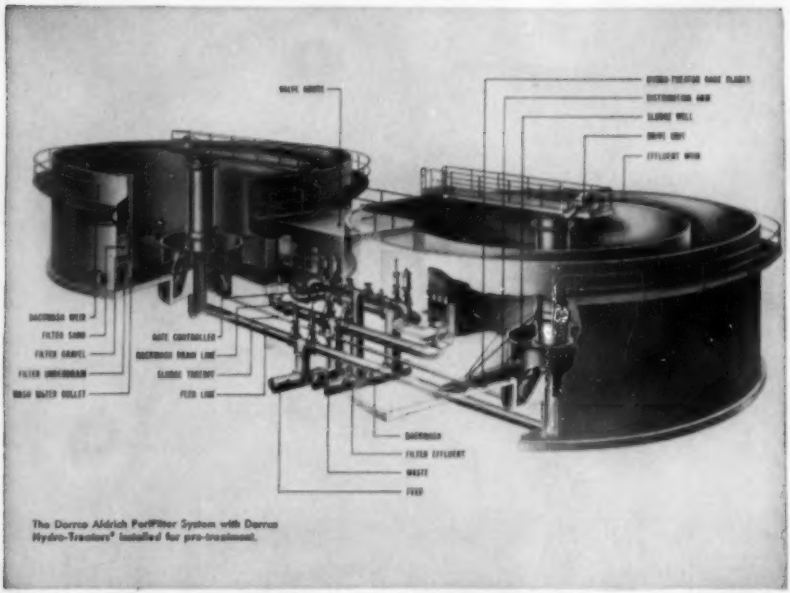

The Dorrco Aldrich PeriFilter System with Dorrco Hydro-Tractors* installed for pre-treatment.

New System Cuts Water Filtration Plant Construction Costs Up to 40%

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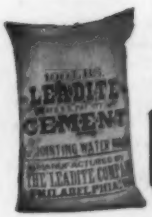

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